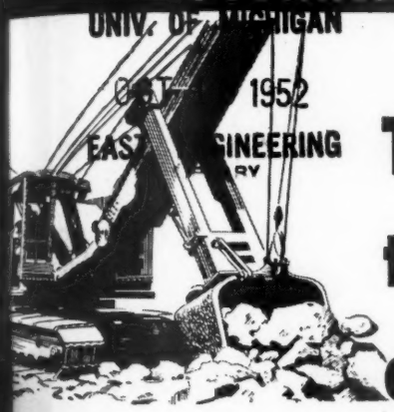
COMBINED EDITION

THE Petroleum Engineer

Canadian Oil Panorama
Does Oil Withdrawal Cause Earthquakes?
What Spurs Oil Progress?
Catalysis in Command of Refining

Drilling and Producing | Refining and Gas Processing | Oil and Gas PIPELINING



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Further details may be obtained by writing our nearest office.

Above: The 12-ft. diam. by 65-ft. catalyst storage tank in the foreground was built by Chicago Bridge & Iron Company for the Continental Oil Company's Denver refinery.

Left: 80,000-bbl. tank with a Hortondome roof at Conoco's Denver refinery. The vapor spaces of ten other tanks storing gasoline are connected to the vapor space in this tank.

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COMBINED EDITION

• Drilling and Producing • Refining and Gas Processing • Oil and Gas Pipelining

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Oil Women Are Here to Stay

OIL and gas and supply companies looked with interest, some amusement, and considerable pride at the earnest and enthusiastic Desk and Derrick women who held a large organizational meeting in Houston, Texas, last month. The men have lent every assistance in helping the women have their own organization, one which is unusual in U. S. industry. This is a report to men of the petroleum industry who know better than most the value of good organization.

In the first place, the field of endeavor has broadened and clubs have multiplied since Inez Awtry sought her employer's approval for a get-acquainted meeting of New Orleans oil women. In less than three years there are Desk and Derrick Clubs in some 40 cities of the United States and Canada.

The important factor is not the organizing but what the organization proposes to accomplish.

The clubs have a stated purpose—to gain a better understanding of the industry. Members meet for lectures and films, and go on field trips to see for themselves how operations are carried on by oil and gas and allied industries.

This Desk and Derrick educational program is directed toward two main goals —one is helping members to do a better job in their companies and the other is teach-them to be better representatives of their industry in relations with the public.

It is early to measure the actual progress in reaching these objectives. It it not too early to say that if the purpose and hopes of Desk and Derrick are realized a new great force will be added to others in the persevering effort to improve industrial and public relations.

The constant threat to the industry's fight to remain a free enterprise is the public distrust of oil and gas operations that it does not understand. As women of the industry broaden their knowledge, they may be better interpreters of the industry to the public than the trained geologists and engineers and chemists, who have trouble simplifying the technical problems, which they know to be far from simple.

So far the most significant outcome of the Desk and Derrick Clubs seems to be a more enthusiastic approach of the members toward their jobs and their industry. This attitude is hard to define yet evidence of such a new spirit was everywhere at the Houston convention. It was revealed in uncommon friendliness, in eagerness to participate in the program, in the pleased display of company affiliations on identification tags. Conventioneers sought members who worked for their company from other cities as eagerly as they sought new friends. Confined to words this may seem a small factor but it represents the difference between working for a company and working in a company. The new attitude has developed from greater fellowship, from better understanding of oil and gas operations, greater confidence in ability to do a good job, and from a new feeling of being a part of a great and fascinating industry. It makes the time spent working, worth living.

Successful men have found that the pursuit of business and industry can bring satisfaction and pleasure than can be more important than the money his efforts earn. This appears especially true in the petroleum industry. When women were thrown into the economic world of modern times they worked almost solely for income. Through the activities of the Desk and Derrick Clubs women of the petroleum industry now seek the intangible but invaluable interest in achieving so that they too can turn their jobs into careers.—E. A.

"Oilwell" 66

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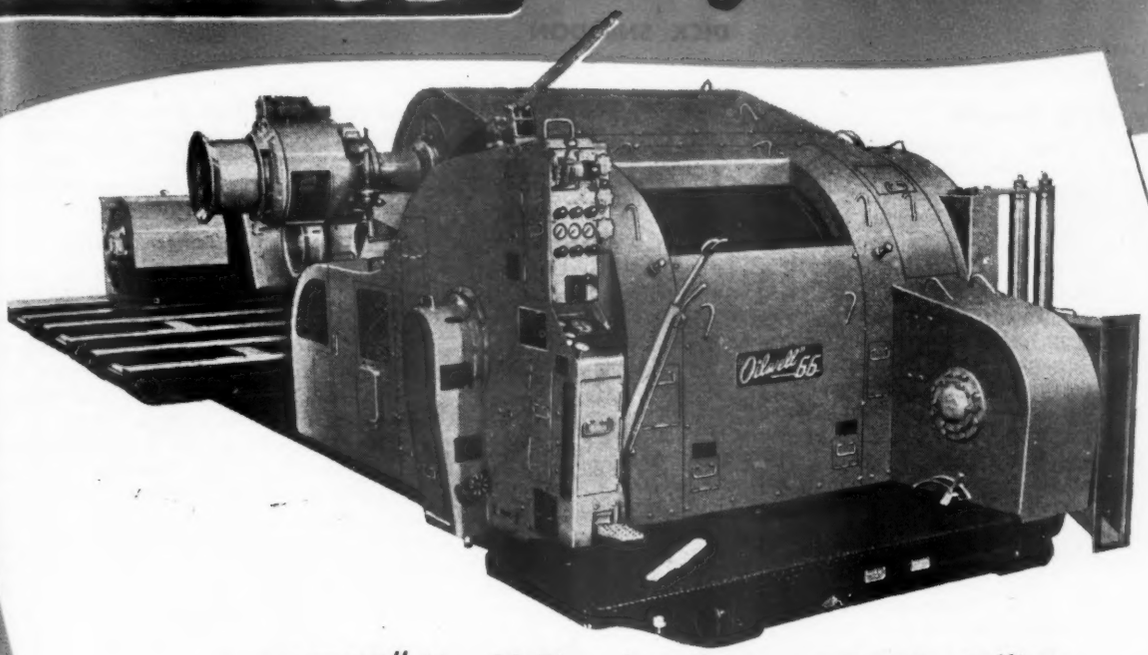

"OILWELL'S" No. 66 Rig..for 4,500 to 7,500 ft. drilling

"OILWELL'S" No. 76 Rig..for 7,000 to 10,000 ft. drilling

"OILWELL'S" No. 96 Rig..for drilling beyond 10,000 ft.

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MEDIUM DEPTH DRILLING

"OILWELL'S" No. 66 Draw Works and companion No. 550 Drive is a compact rig—embodying the latest design features and is adapted for two or three engines and one or two pump drives. In this one rig, an operator has a choice of either a straight mechanical draw works or a torque convertor rig. By a simple change, possible in the field, the draw works can be changed from six speeds forward to three speeds forward when using torque convertor equipped engines. This rig also has the many field proven features which have contributed so much to the ease of handling and the outstanding performance of larger "Oilwell" rigs.

With or Without Torque Convertor

The No. 66 Draw Works has a selection of six forward and one reverse drum speed with three forward and one reverse rotary speed.

The No. 63-T Draw Works for use with two or three torque-convertor-equipped engines, has three forward and one reverse drum speeds and three forward and one reverse rotary speeds.

These rigs are basically the same and can easily be converted from one type to the other. Both rigs have a built-in, high-speed, high-capacity hydromatic brake. The draw works can be assembled as a unit with the drive and can be moved complete with engines; or when desired, the drive with engines can be separated from the draw works for moving separately.

Ask . . . your "Oilwell" Representative for all the facts about this newest "Oilwell" Rig—or write for your copy of Booklet No. 1-53.

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PETROLIC PERSONALITIES

DICK SNEDDON

M. O. Nearly Gets Caught

Congratulations to Tommy Johnston who has moved to Houston, Texas, and will henceforth officiate as executive vice president of Johnston Testers, Inc. We remember when Tommy was a much lesser pumpkins than he is today and, while working directly for M. O. Johnston as a field engineer, had landed formation testing equipment at a well in West Texas, preparatory to making a test the next morning. That afternoon when he had gone back to town, M. O. showed up at the well, announcing his attachment to the Johnston organization, but not mentioning either his name or his position. He was promptly put to work, making-up the testing equipment, and he applied himself vigorously and without demur for some time. But, it was a hot day and along about 3 o'clock M. O. gave up. He had picked up his jacket and was about to take off, when the drilling superintendent yelled, "Hi there! Where do you think you're going at this time of day?" "It's too hot," replied M. O., "I'm going back to the hotel." "Is that so?" said the supe, sarcastically, "Well, by so and so, you'd better not let Tommy Johnston catch you!"

Incidentally, as part of this same institutional change, Bill Bettis becomes vice president in charge of western division and export, with headquarters in Los Angeles. Bill had a great deal to do with the origin of that illustrious association, the Nomads; is a past president of the Los Angeles chapter, and is one of the best known and most esteemed equipment executives of the west. He has been a fine host over many years to countless petroleum emissaries from foreign fields and is just as well acquainted and regarded in the remoter outposts as he is in his home bailiwick.

Expatriate Returns Home

We hear tell that Jim Gregory is going back to California from Texas, to accept a position as vice president in charge of field operations for Terminal Drilling and Harbor Production Companies in Los Angeles. Jim is a high-ranking graduate of Caltech and is a descendant of a pioneer oil family. His dad, Holt Gregory, was a biggie in Union Oil Company's land department for yahs and yahs while we were struggling for recognition there. Jim is a quietly behaved sort of chap who ordinarily finds his diversion in a basement machine shop where he tinkers with all sorts of mysterious contraptions. He knows the production end of the oil business thoroughly and is never happier than when he is in it up to his neck.

Ituri Forest Organizes D & D Club

There is a fearful epidemic of travel among the oil people these days not only inside the continental limits of the United States, but in all areas of the world. Bill Pemberton, the Paul Bunyan of the petroleum explorationists, did some recent exploring on his own account in the heart of Africa. Bill went on safari into the game country and brought back some interesting mementoes, one of the most unusual being a photograph of the Desk and Derrick Club of Ituri Forest. Bill had the girls pose in the altogether for this, which of course is their usual custom, and for a modicum of protection they held a long banner proclaiming their affiliation with the D & D's of America.

Travel and Vacations

Henry Salvatori and family have just returned as we write from an extended visit in Europe where they seem to have had a thoroughly enjoyable time. Archie MacDonald is frequenting his old haunts again after a jaunt that took him half way around the world. Jim MacDonald, the Chain Belt chap is leaving for a cruise around the Latin-Americas that will keep him from despoiling the western golf courses for a month or two. O. I. "Tork" Torkelsen, the British American exploration chief up in Toronto is reported to be planning a trip to Los Angeles to take up the little matter of currency exchange with Ham Bell, the drilling contractor. Tork paid off a bet with a Canadian dollar bill and demanded a refund to compensate for the exchange difference. Ham conceded the higher value of the Canadian bill and sent back a grist of Mexican centavos to take up the slack. The argument is still going on!

Birds of a Feather Flock to Santa Maria

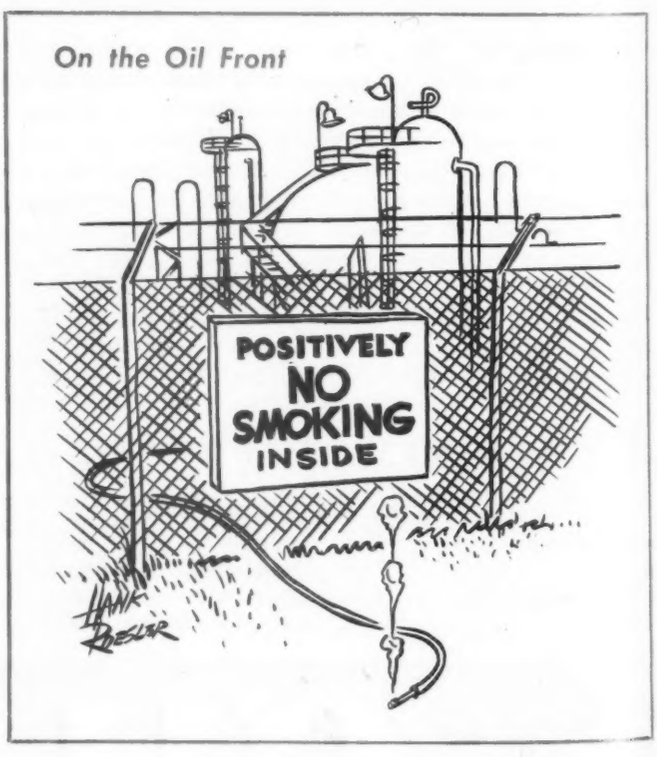
The Petroleum Production Pioneers gathering at Lompoc and Orcutt has started a new deal in oil conservation—traveling in packs. Bill Wilson, the lurid-shirted prexy of Web Wilson Oil Tools, aided and abetted by the Los Angeles Chapter Nomads, took up a sizable busload of passengers to Santa Maria and brought them back the same day. Frank Smith, of Byron Jackson Service took up another 16 by plane.

Cy Rubel, master of ceremonies at the dedication service, and current president of the Petroleum Production Pioneers also flew in and out the same day with several passengers. A fairish representation stayed overnight, however, at the noted Santa Maria Inn and other nearby hostelries, and the traffic between rooms was terrific. We heard of one fellow who shall be nameless—he put in a call for 6:30 a.m. and didn't get to bed until 7.

It Didn't Get Away

Great accounts are circulating in these parts about a recent fishing trip off the Island of Catalina that was productive of a lovely day's outing and one marlin that weighed 132½ lb and walked on its tail beautifully. The fortunate Waltonian was Clarence White, prexy of Oil Well Manufacturing Corporation, and the guests aboard his cabin cruiser, *The Red Devil*, were Henry Pullman, the Baker Oil Tools export chap and Mrs. Pullman; R. E. Irby of Colombian Petroleum Company, New York, and Mrs. Irby; Mrs. Nina Murren, Houston, Texas, and Mrs. Clarence White (see photo on page E-6).

It took Clarence an hour and twenty minutes to land the obstinate marlin which, incidentally, was his third. An outstanding feature of the total adventure was that Mrs. Irby took over the wheel and did a job of navigating that would have done credit to Captain Ahab of Moby Dick fame.



HERE'S WHY ENGINEERS SELECT YOUNG HEAT EXCHANGERS

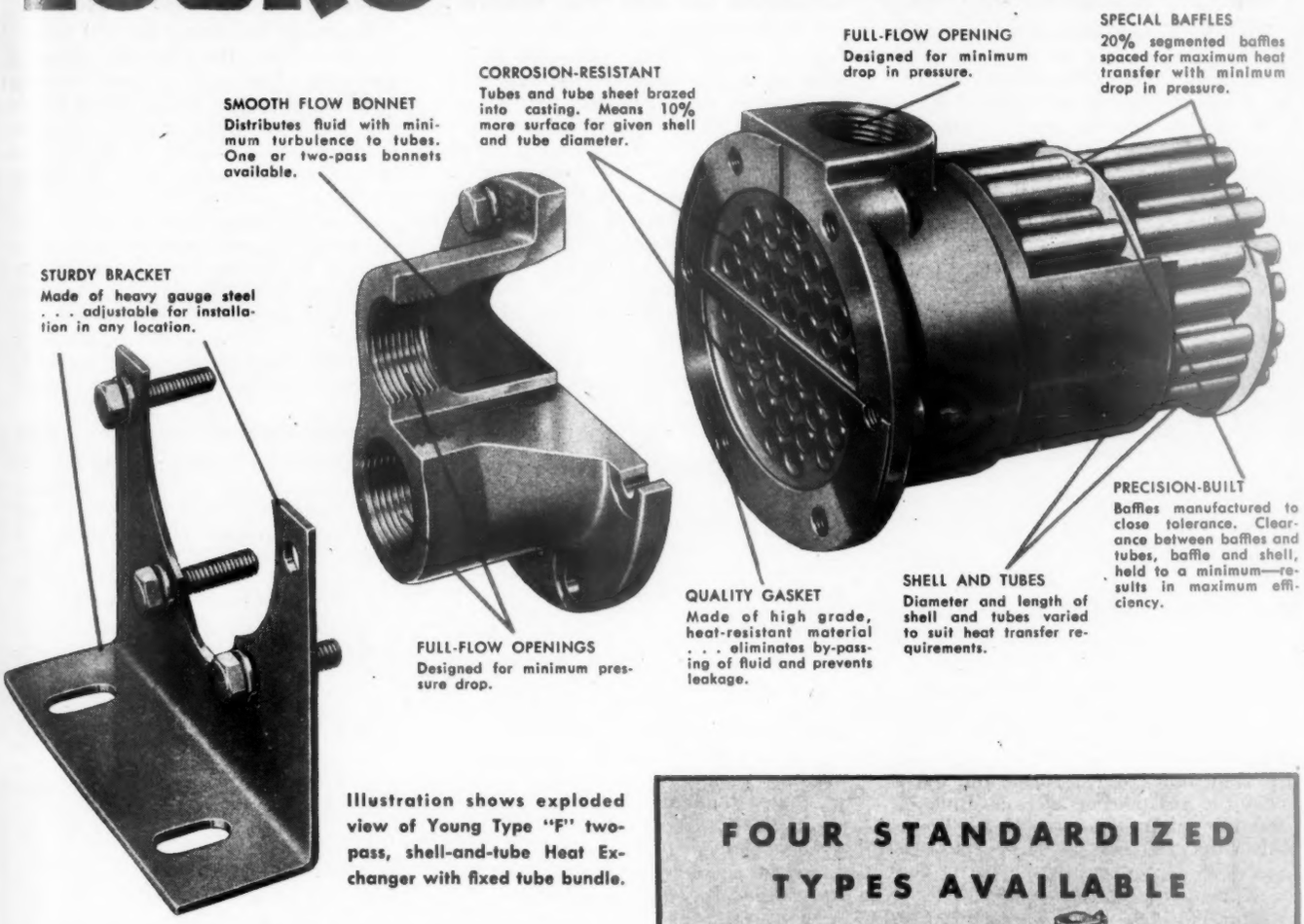

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Illustration shows exploded view of Young Type "F" two-pass, shell-and-tube Heat Exchanger with fixed tube bundle.

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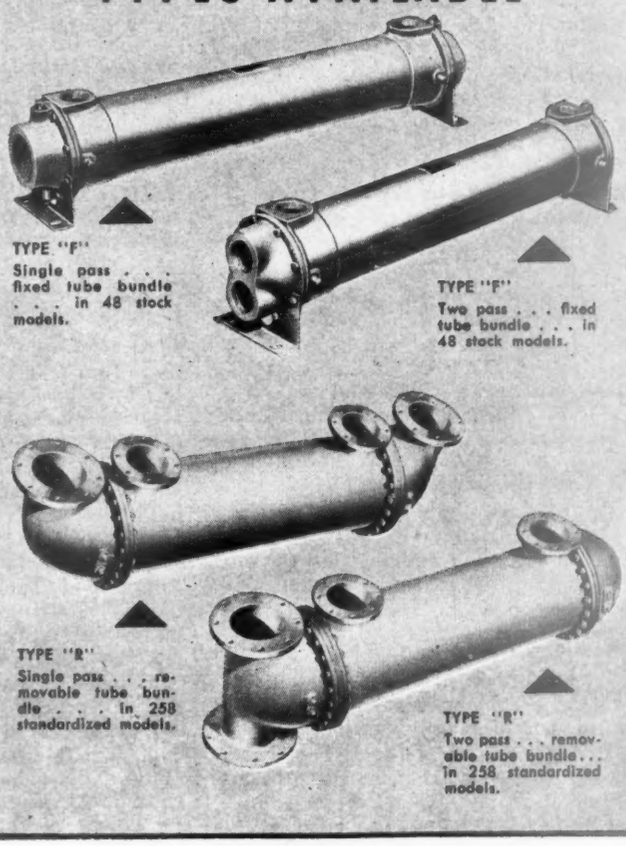


TYPE "F"
Single pass . . . fixed tube bundle . . . in 48 stock models.

TYPE "F"
Two pass . . . fixed tube bundle . . . in 48 stock models.

TYPE "R"
Single pass . . . removable tube bundle . . . in 258 standardized models.

TYPE "R"
Two pass . . . removable tube bundle . . . in 258 standardized models.

HIGHLIGHTS IN OILDOM

Tariff Cuts Denounced by IPAA

The small oil company, about which the government has shown much concern lately in its cartel charges against seven major companies, received latest news of tariff cuts on imported oil with some foreboding. President Truman's announcement that duties on all oil imports from Venezuela would be slashed by as much as 50 per cent in some instances came as a disappointment to Independent Petroleum Association of America, which had opposed the new pact. Russell B. Brown, IPAA general counsel said, "The price increase to the importing companies discriminates against the domestic producer whose crude oil price has been frozen at the 1947 level." He contended that the tariff cut won't be passed on to customers, who instead will have to pay more taxes to make up the $30,000,000 loss to the U. S. treasury. IPAA has long tried to get OPS to remove crude oil price ceilings.

U.S. Oil Output Sets New Mark

Output of crude oil and lease condensate production set its second record in the U. S. for the week ended September 13. The American Petroleum Institute has reported that crude and condensate production during that week averaged 6,460,500 bbl a day, 178,300 bbl daily above the year-earlier average. Bulk of the crude oil increase was due to Texas daily gain of 26,650 bbl from the week preceding. Gasoline production totaled 24,132,000 bbl, 912,000 bbl more than was produced in the preceding week, and 196,000 bbl more than the record set in the last week of August. This figure compared with 21,710,000 bbl produced the week ended September 15, 1951, API reported.

Colorado to Vote on Tax Levy

The people of Colorado will vote on a gas and oil severance levy in the November general election. Proposed tax is 5 per cent on all oil and gas produced in the state, which would be set aside for schools, and will be voted on in a form of a constitutional amendment. Other states with oil severance taxes are Louisiana, Mississippi, Oklahoma, Texas, and Arkansas.

Elk City Unitization in Effect

The required number of royalty owners have approved the Elk City oil field, Beckham County, Oklahoma, unitization program and the plan was put into effect last month. It is believed that with the 95 extra wells brought in, a saving of 23,000,000 cu ft of gas daily will be effected. Ratification of the unit action by the state school land commission brought the number of royalty owners approving the move to 63 per cent. The Commission approved extension on a basis of flow of 50 per cent on the reservoir and 50 per cent on acreage involved.

Canadian Oil Sets New Record

Canadian crude oil production for the first six months of the year rose 30 per cent above the same period last year reaching a new high for the period. June saw a 14 per cent increase from a year earlier, with the month's output reaching 5,398,547 bbl, compared to 4,756,710 in June last year. Total output for the first half of 1952 amounted to 24,863,931 bbl up from 19,970,351 bbl the first half of 1951. Natural gas production in June amounted to 6,214,798,000 cu ft, compared with 4,845,683,000 in the same month last year. Half year total was 49,080,120,000 cu ft compared with 40,764,605,000, in the same months of 1951. Alberta crude accounted for 5,230,801 bbl of total output.

'Get Rich Quick' Schemes Out

Durwin Bond, Little Rock, Arkansas, oil man has advised the man with a few hundred or thousand dollars to spend getting rich in the oil industry, to leave it alone. "In the old days the little man could make a deal," Bond said, "but only in rare instances can he do it today." Bond added that it took $50,000 to drill an oil well and if the prospects look good a company will come in right away and drill. Where the little man might stop at 3000 ft, the oil company will keep going because it has too much at stake. Bond also explained that it would take a lot of talking to get the average person today to put in any money in an oil venture because he has been duped so often by shysters he is leery.

Water Disposal Costs High

Humble Oil and Refining Company has come up with some interesting figures. In 1951 that company produced 180,000,00 bbl of water, compared with 127,000,000 bbl of crude oil, and spent more than $1,000,000 in disposing of the water.

Fringe Benefits Soar

Fringe benefits to employees amounted to $975 each in 1951, in the refining petroleum industry in addition to regular payroll costs. This was revealed in a survey by the Economic Research Department of the United States Chamber of Commerce. This figure exceeded by a wide margin all other manufacturing industries, which averaged $599 per employee, as well as non-manufacturing industries, including insurance companies and banks. Legally required benefits in the petroleum refining industry were only $121 per year or 2.8 per cent of the total payroll, but the total for voluntary payments was $854 per year or 19.7 per cent. Fringe benefits include a broad list of employer costs including social security, hospitalization and accident benefits, profit-sharing, paid vacations, bonus arrangements, etc.

Ohio River Acreage Leased

Kentucky has leased out 150 miles of the lower Ohio River to Ohio River Oil Company. The state is given the usual 1/8 share of any oil or gas found according to terms of the contract. Area included runs from Lock 45 in Breckenridge County to Lock No. 50 in Crittenden County, along the borders of Illinois and Indiana. If no drilling is done on any of the acreage leased in 10 years, it must be returned to the state. Land owners in Kentucky own land from the Kentucky side out to midstream, and from there to the low-water mark on the opposite shore is owned by Kentucky, which is the area that the state leased.

Science Students Get More Pay

Higher salaries were offered this year to June graduates of the California Institute of Technology, Professor Donald S. Clark, director of placements, reported to Caltech President Lee A. DuBridge. They averaged $5 to $60 per month more than last year, he said. Salaries as high as $527 were offered students with the bachelor of science and master of science degrees. Top figure for the advanced engineers degree was $585, while the PhD degree commanded salaries to $750. The median monthly salary for bachelors was about $340, for masters $405, engineers $475, and for PhD's $495.

IPAA Condemns Price Control

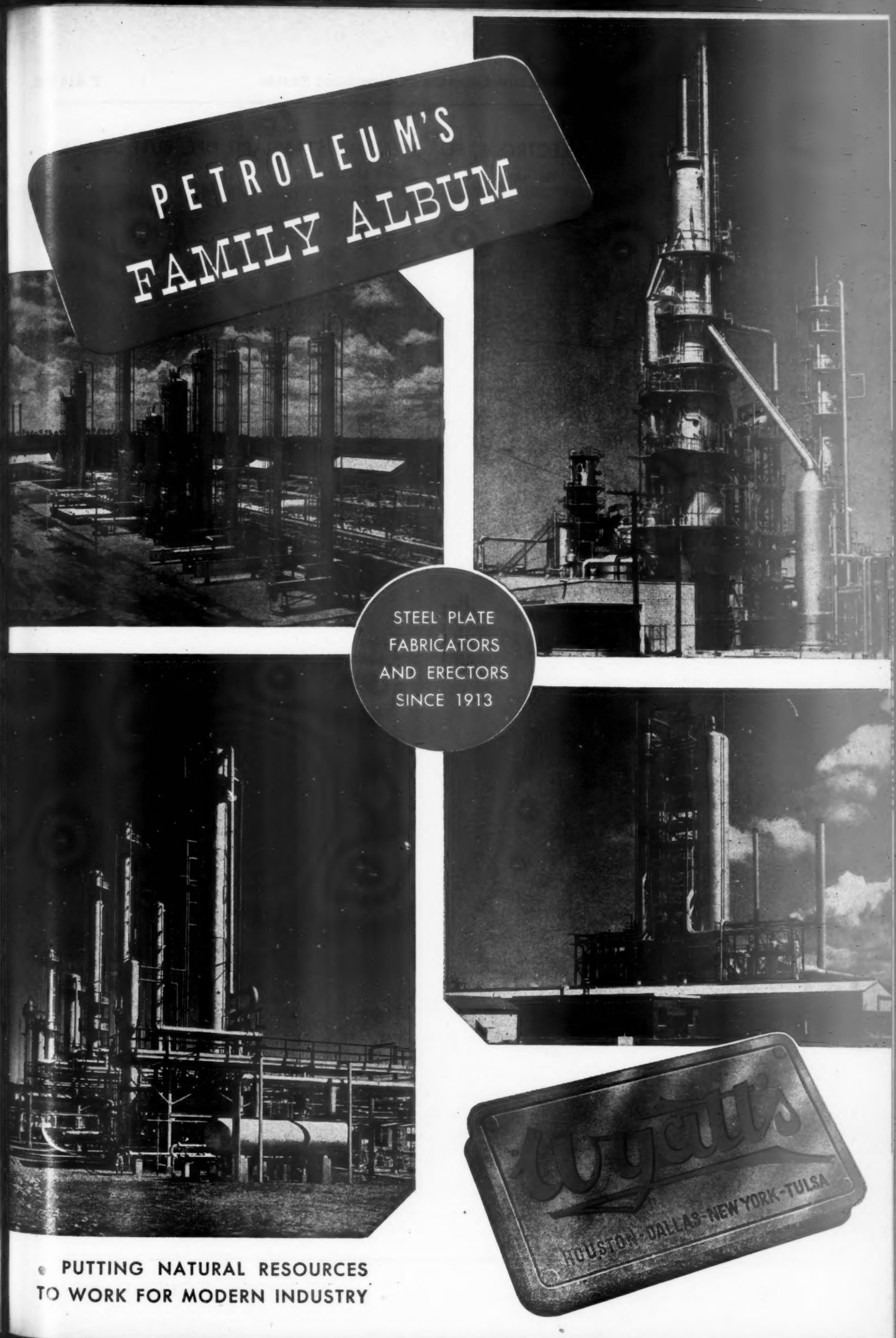
A spokesman for the Independent Petroleum Association of America has condemned as "a threat to the security of the nation" the action of the Office of Price Stabilization in refusing to decontrol the price of crude petroleum. George H. Bruce, president of Aladdin Petroleum Corporation, and chairman of the Price Advisory committee of IPAA, on his return from a meeting of that group in Fort Worth, Texas, said "unrealistic and unsound price controls are resulting in increasingly serious problems.

"There was no need or justification for the imposition of crude oil price controls. There is even less reason to continue them. Crude petroleum is in ample supply. There is no basis for, or threat of, unreasonable price increases."

Alberta Resources Said Vast

The Province of Alberta in Canada was cited for its vast resources, including producing oil fields, petroleum supplies in the Athabasca River oil sands, plus half of Canada's coal reserves, uranium, and waterpower, at the Interstate Oil Compact Commission meeting in Banff, Alberta, recently.

Minister Prudham reported that the Athabasca tar sands reputedly hold more oil than any other area in the world, and "even now science is fashioning a key to unlock its source of power."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PUTTING NATURAL RESOURCES
TO WORK FOR MODERN INDUSTRY

SPEEDS AND AMOUNT OF ELECTRODE, FOR WELDING STANDARD PIPE, BUTT JOINTS

This table may be filed under P 622.320.

Size of Pipe		Current, amps.	Minimum arc volts	Arc time, minutes per joint	Number of passes	Electrode size, in.	Pounds of electrode per joint
Diameter, in.	Thickness, in.						
2 (see Fig. 1)	0.154	120 140	25	5.5	1 2	5/32	0.35
3 (see Fig. 1)	0.216	120 140	25	7.0	1 2	5/32	0.44
4 (see Fig. 2)	0.237	120 160	25	9.0	1 2 3	5/32 3/16 3/16	0.64
5 (see Fig. 2)	0.258	120 160	25	11.3	1 2 3	5/32 3/16 3/16	0.81
6 (see Fig. 2)	0.280	120 160	25	13.5	1 2 3	5/32 3/16 3/16	0.96
8 (see Fig. 2)	0.322	150 170	25	17.8	1 2 3	3/16	1.33
10 (see Fig. 3)	0.365	150 170	25	22.0	1 2 3 4	3/16	1.65
12 (see Fig. 3)	0.375	150 170	25	26.5	1 2 3 4	3/16	2.0
14 (see Fig. 3)	0.375	150 170	25	31.3	1 2 3 4	3/16	2.3

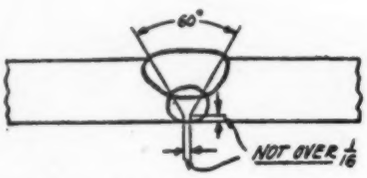


Fig. 1. Type of butt weld for 2- and 3-in. pipe

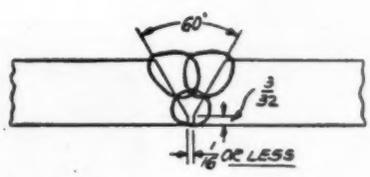


Fig. 2. Type of butt weld for pipe 4, 5, 6, and 8 in. in diameter

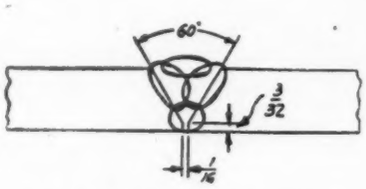
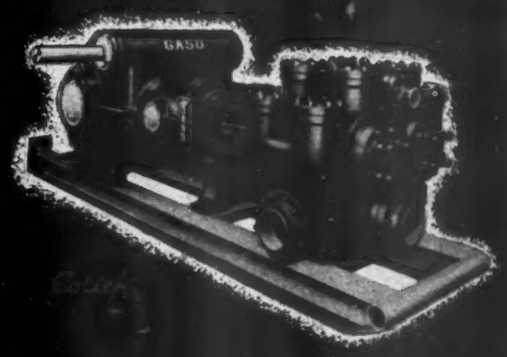


Fig. 3. Butt weld for pipes with diameters of 10, 12, and 14 in.

Data courtesy The Lincoln Electric Company, Cleveland, Ohio.

GENERAL SHERMAN, WORLD'S LARGEST TREE

GASO World's Best Known Portable Pumps



SIX FOOT MAN ON SAME SCALE AS TREE

Specifications of the General Sherman Bigtree, Sequoia National Park: Diameter, 36½ feet. Circumference, nearly 115 feet. Height, 272.4 feet. Lumber content: 600,-120 board feet. Age 3000 to 4000 years.

We confess that no Gaso Pump has yet attained the age of the Bigtree. But we can point to many of our earliest models still doing their daily stint, with a history of economical performance that would be unbelievable were it not backed up by accurate cost records.

That's what cost-conscious buyers look for in pumping units—completely dependable service at minimum cost. And that's what makes GASO PUMPS predominantly first in the favor of pipeline men.

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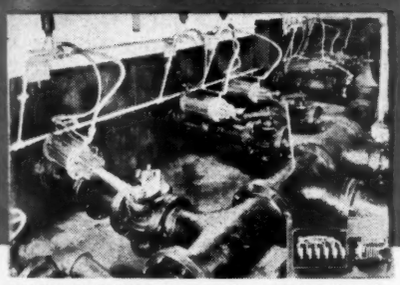
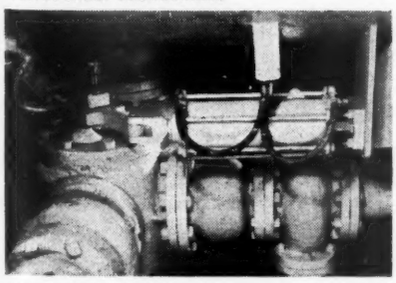
BASE TEMPERATURE MULTIPLIERS, 60 DEG. F. ABS.

Obs. temp.	Multiplier	Obs. temp.	Multiplier	Obs. temp.	Multiplier	Obs. temp.	Multiplier
0	1.1304	60	1.0000	120	0.8966	180	0.8125
1	1.1280	61	0.9981	121	0.8950	181	0.8112
2	1.1255	62	0.9962	122	0.8935	182	0.8100
3	1.1231	63	0.9943	123	0.8919	183	0.8087
4	1.1207	64	0.9924	124	0.8904	184	0.8075
5	1.1183	65	0.9905	125	0.8889	185	0.8062
6	1.1159	66	0.9886	126	0.8874	186	0.8050
7	1.1135	67	0.9867	127	0.8859	187	0.8037
8	1.1111	68	0.9848	128	0.8844	188	0.8025
9	1.1087	69	0.9830	129	0.8829	189	0.8012
10	1.1064	70	0.9811	130	0.8814	190	0.8000
11	1.1040	71	0.9793	131	0.8799	191	0.7988
12	1.1017	72	0.9774	132	0.8784	192	0.7975
13	1.0994	73	0.9756	133	0.8769	193	0.7963
14	1.0970	74	0.9738	134	0.8754	194	0.7951
15	1.0947	75	0.9720	135	0.8739	195	0.7939
16	1.0924	76	0.9701	136	0.8725	196	0.7927
17	1.0901	77	0.9683	137	0.8710	197	0.7915
18	1.0879	78	0.9665	138	0.8696	198	0.7903
19	1.0856	79	0.9647	139	0.8681	199	0.7891
20	1.0833	80	0.9630	140	0.8667	200	0.7879
21	1.0811	81	0.9612	141	0.8652	201	0.7867
22	1.0788	82	0.9594	142	0.8638	202	0.7855
23	1.0766	83	0.9576	143	0.8624	203	0.7843
24	1.0744	84	0.9559	144	0.8609	204	0.7831
25	1.0722	85	0.9541	145	0.8595	205	0.7819
26	1.0700	86	0.9524	146	0.8581	206	0.7808
27	1.0678	87	0.9506	147	0.8567	207	0.7796
28	1.0656	88	0.9489	148	0.8553	208	0.7784
29	1.0634	89	0.9472	149	0.8539	209	0.7773
30	1.0612	90	0.9455	150	0.8525	210	0.7761
31	1.0591	91	0.9437	151	0.8511	211	0.7750
32	1.0569	92	0.9420	152	0.8497	212	0.7738
33	1.0548	93	0.9403	153	0.8482	213	0.7727
34	1.0526	94	0.9386	154	0.8469	214	0.7715
35	1.0505	95	0.9369	155	0.8455	215	0.7704
36	1.0484	96	0.9353	156	0.8442	216	0.7692
37	1.0463	97	0.9336	157	0.8428	217	0.7681
38	1.0442	98	0.9319	158	0.8414	218	0.7670
39	1.0421	99	0.9302	159	0.8401	219	0.7658
40	1.0400	100	0.9286	160	0.8387	220	0.7647
41	1.0379	101	0.9269	161	0.8374	221	0.7636
42	1.0359	102	0.9253	162	0.8360	222	0 7625
43	1.0338	103	0.9236	163	0.8347	223	0.7613
44	1.0317	104	0.9220	164	0.8333	224	0.7602
45	1.0297	105	0.9204	165	0.8320	225	0.7591
46	1.0277	106	0.9187	166	0.8307	226	0.7580
47	1.0256	107	0.9171	167	0.8293	227	0.7569
48	1.0236	108	0.9155	168	0.8280	228	0.7558
49	1.0216	109	0.9139	169	0.8267	229	0.7547
50	1.0196	110	0.9123	170	0.8254	230	0.7536
51	1.0176	111	0.9107	171	0.8241	231	0.7525
52	1.0156	112	0.9091	172	0.8228	232	0.7514
53	1.0136	113	0.9075	173	0.8215	233	0.7504
54	1.0117	114	0.9059	174	0.8202	234	0.7493
55	1.0097	115	0.9043	175	0.8189	235	0.7482
56	1.0077	116	0.9028	176	0.8176	236	0.7471
57	1.0058	117	0.9012	177	0.8163	237	0.7461
58	1.0039	118	0.8997	178	0.8150	238	0.7450
59	1.0019	119	0.8981	179	0.8138	239	0.7439

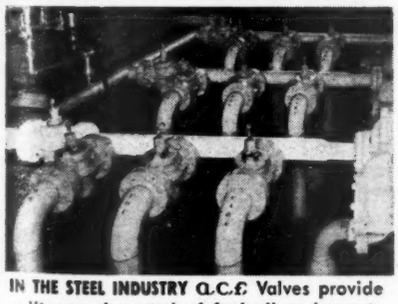
This table is for the correction of a volume of gas at the observed temperature to a base of 60 deg. F. Abs. The multiplier opposite the observed temperature times the volume of gas equals the corrected volume at 60°F. From the formula $\frac{460 + 60}{460 + t\ (obs.)}$



IN SEWAGE PLANTS, these electrically-timed, fully-automatic, air-cylinder operated a.c.f. Valves shear obstructions.



IN CHEMICAL PLANTS air-operated a.c.f. Valves offer super-dependability...self protected from abrasive and corrosive action.



IN THE STEEL INDUSTRY a.c.f. Valves provide split-second control of fuel oil and gas to furnaces and coke ovens.

SPLIT SECOND ROBOT CONTROL

a.c.f. CYLINDRICAL Plug Valves are ideal for all types of automatic operation: hydraulic, electrical, or air operated. The quick quarter-turn from full-open to full-closed is always sure as there's no wedge effect to cause jamming in the seat. In addition, all bearing surfaces are lubricated for easy turning. Sound reasons to insist on a.c.f. Plug Valves for all automatic valve operations.

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Representatives in 50 Principal Cities

LETTERS

Filter or No

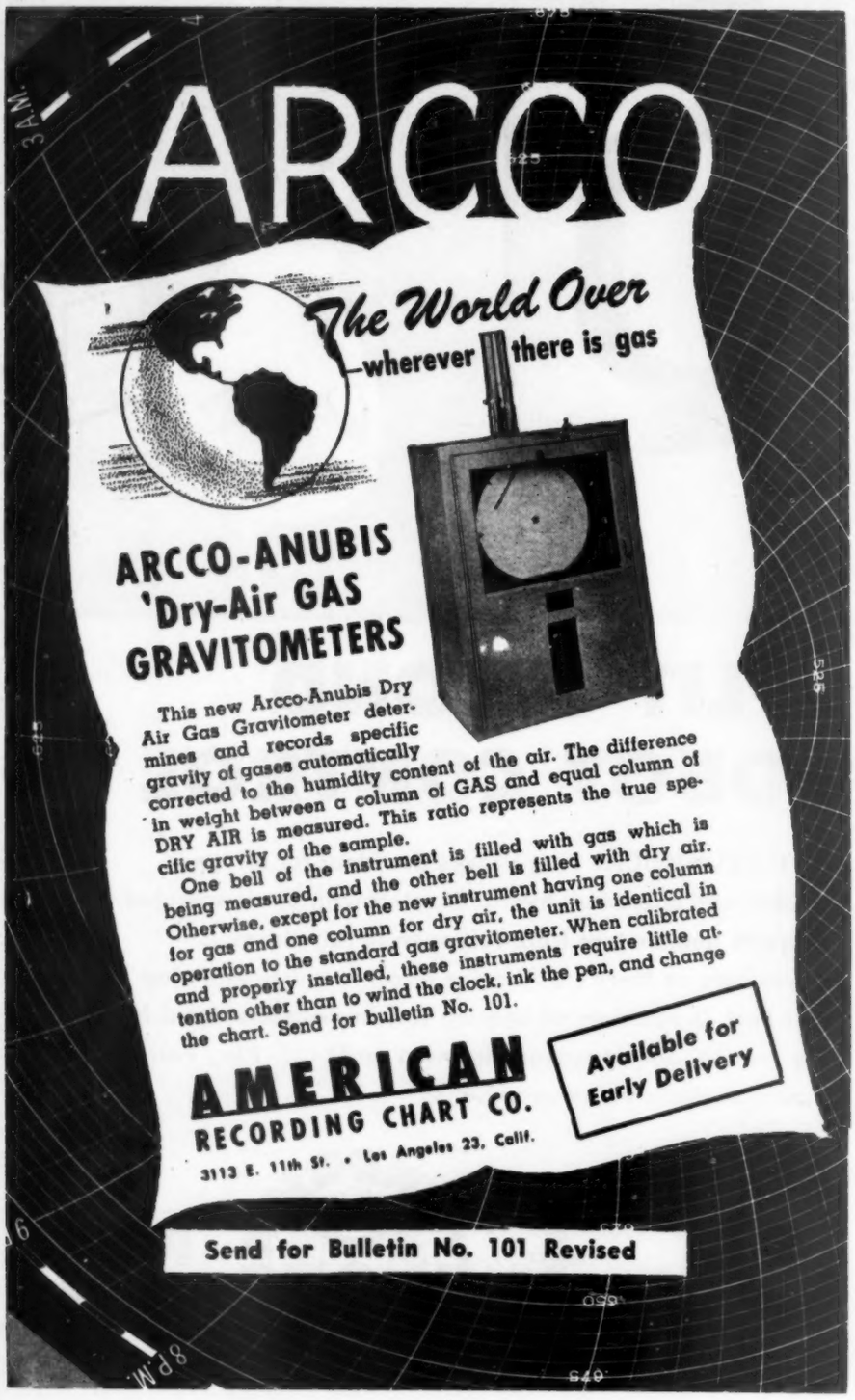
To The Petroleum Engineer:

I was very much interested in the article entitled "Lubricating and Fuel Oil Filters" by J. F. Austin, which appeared in the June 1952 issue of The Petroleum Engineer. I consider that this brief article very ably covered the chemical and physical characteristics of oil filters.

I would appreciate very much to have your candid reaction as to fundamental economics of lubricating oil filters. I am especially interested in having your opinion as to the relative value of an oil filter cartridge as compared to a change of oil. Under present conditions I find that servicing lubricating oil filters with renewal of filter cartridge costs the same as five quarts of lubricating oil. This brings me to inquire as to which is really more valuable to the automobile motor, a new filter, or a complete change of oil.

J. I. Cormany

The Gas Service Company
Kansas City, Missouri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This new Arcco-Anubis Dry Air Gas Gravitometer determines and records specific gravity of gases automatically corrected to the humidity content of the air. The difference in weight between a column of GAS and equal column of DRY AIR is measured. This ratio represents the true specific gravity of the sample.
One bell of the instrument is filled with gas which is being measured, and the other bell is filled with dry air. Otherwise, except for the new instrument having one column for gas and one column for dry air, the unit is identical in operation to the standard gas gravitometer. When calibrated and properly installed, these instruments require little attention other than to wind the clock, ink the pen, and change the chart. Send for bulletin No. 101.
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Following is the answer of J. F. Austin to the above letter:

The questions you pose in your letter, with reference to the subject "Lubricating and Fuel Oil Filters" represent almost universal reaction, to this much "mooted" subject. The previous article on this over-all subject appearing in the May issue of *The Petroleum Engineer*, will aid you in arriving at some personal conclusions on the matter of oil changes, and the relative value of filters.

I assume from your letter that you are referring to a change of oil on your own personal automobile, and that you are following the much out moded practice of changing the oil every thousand miles, or close to that mileage point. If this is the case, and you are changing the filter cartridge each time that you change oil, it would be poor economy for you to use an oil filter in particular if you, like most people, trade cars at a low mileage point. The purpose of an oil filter basically, is to extend oil life, and prevent engine wear.

Even if you do change oil every thousand miles, if you intend to drive the car to the limits of its possible mileage output, then this oil change practice would still require the use of an efficient oil filter to prevent engine wear. The amount of abrasive that gets into your engine crankcase every thousand miles is quite amazing. The prompt removal of such abrasives is of extreme importance if you intend to minimize costly engine wear.

Frankly, if engine temperatures are properly maintained, the cooling system kept clean to transfer heat, and the air cleaner frequently serviced, as well as the oil filter, oil life can be appreciably extended, with little noticeable engine wear. The engine will run clean, and a clean engine is a long lived engine. The filter cartridge and oil should be changed at the same time, which should be at the point of oil discoloration in the case of mineral oils, and at the point of dirt lines in the oil when tested on filter paper in the case of new detergent oils. The minimum mileage figure for both oil and cartridge change, with a good filter should be from 3000 to 8000 miles, depending upon the type of operation the vehicle is subjected to. This means real economy, in oil, filter cartridges, and engine life. Deluxe Products Corporation.

J. F. Austin

Dallas, Texas

Earthquake

To The Petroleum Engineer:

Bakersfield and vicinity has been hard hit by two severe earthquakes, the first of which came on July 21. It epicentered on a 50-mile arc between the San Andreas fault west of Maricopa, at its western extremity, and the town of Caliente, northeast of Bakersfield, at its eastern extremity. Much damage was caused. At this time, my mountain home was severely damaged and remains unrepaired.

The quake of July 21 was followed by another in the afternoon of August

Greater Liquid Recovery from Gas Wells

can be yours with the

BS&B Glycol Injection System*

of Low Temperature Separation

DEWPOINT 20° to 40°F. BELOW SEPARATOR TEMPERATURE

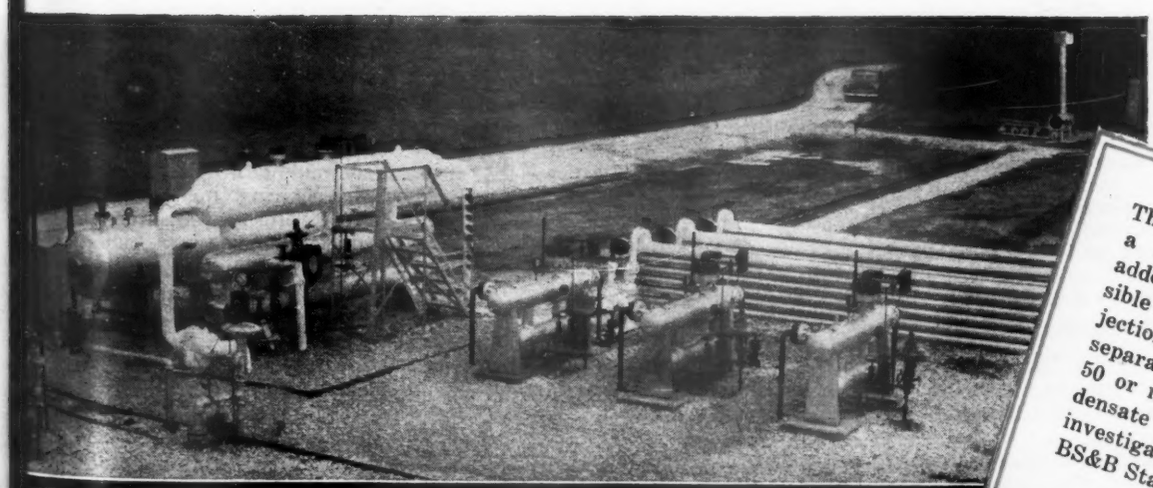
The lower the separator temperature . . . the more liquid recovery you're going to get.

But as you cool the wellstream there's the problem of hydrate formation. Glycol injection permits cooling the wellstream well below the hydrate point before expansion. By using a regenerative heat exchanger lower separator temperatures can be obtained than are possible in even the most efficient conventional low temperature separation systems. This lower temperature allows a greater liquid recovery. In practical terms the BS&B Glycol Injection System is really as simple as that.

More and more operators of gas condensate wells are looking to the BS&B Glycol Injection System as the answer to increasing or maintaining profitable recovery. The full appreciation of the BS&B Glycol Injection System comes when and if the available pressure drop falls below approximately 1000 p.s.i. required for satisfactory operation of conventional LTS units. The BS&B Glycol Injection System will produce pipeline specification gas with available pressure drops as low as 400 p.s.i. — because the wellstream can be cooled below its hydrate formation temperature before expansion.

So—for greater recovery on virtually any gas condensate well, and particularly on a low pressure gas well, why not investigate—and invest in!—a BS&B Glycol Injection System.

* PATENTED



e Glycol Injection System can be applied to one or several wells and to any wellstream h an allowable expansion of 400 p.s.i. or more. It has complete versatility for off-shore or in-swamp use.

The BS&B Stabilizer offers a means of holding the added recovery made possible by the BS&B Glycol Injection LTS System. If your separator system is making 50 or more barrels of condensate per day you should investigate and invest in the BS&B Stabilizer.

BS&B . . . for 60 years a leader in oil and gas producing and refining equipment . . . also manufacturers of Climax Controls, Safety Devices and special fabricated pressure vessels. Ask your BS&B Man. There's one of BS&B's 35 Branches or 17 Sales Offices near you if you're in the Oil Country . . . or write . . .

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Oil and Gas Equipment Division, Dept. 1-C10

2131 Westwood Blvd. **Oklahoma City, Oklahoma**

22. This shock epicentered in Bakersfield as nearly as can now be determined. The damage locally has been extreme. The town is pretty well restricted as it has been declared a disaster area. The clean-up and inspection of structural damage to buildings is proceeding as rapidly as can be expected as the services of qualified engineers are obtained.

As a city councilman, and member of a number of committees now functional, you will appreciate how little time I have . . . .

L. W. Saunders

Intex Oil Company
Bakersfield, California

Accentuates the Positive

To The Petroleum Engineer:

In your July, 1952, issue, we notice, with a great deal of interest, an article by George L. Buckles entitled, "Responsibilities and Opportunities of Management in Water Flooding."

We think this article is timely and well prepared.

W. H. Davison,

Davison and Company
Robinson, Illinois

Corrosion in Kansas

To The Petroleum Engineer:

Please give me the techniques on hollow sucker rods for wells with jip water, which eats up the pipe in four years time. That seems to be our greatest trouble in the Virgil, Kansas field.

I will greatly appreciate having information that is to the point and without any guess work or experimental process. Author of this article (Hollow Sucker Rods Aid Cleaning and Treating Techniques, The Petroleum Engineer, March, 1952, page B-60) is Richard Sneddon. Thanks a million for any information that might be of value to us on this subject.

H. H. Meyer

Central States Drilling Company
Lincoln, Nebraska

Below is the answer from Gilliard Specialties Company:

We are replying to your letter of July 16, 1952, concerning the use of hollow sucker rods in combatting pipe corrosion on oil wells of the Virgil, Kansas field.

Please be assured that the technique employed using the hollow sucker rods is quite simple and very effective. This statement is not guess work, but is based on the results of our actual use of the rod in injecting corrosion inhibitor in wells in some of the corrosive oil fields of Southern California.

The Gilliard Specialties Company is the originator and exclusive source for purchasing the hollow rod. We also operate a service organization and can assure you of competent instruction and supervision in the use of the rod should you require it. Briefly, the procedure employed in the injection of a corrosion inhibitor is as follows:

1. Hollow rods replace conventional solid sucker rods either for the entire string length or to the maximum depth of pipe corrosion.

2. A cross-over nipple or nipples containing a ball check valve is placed in the string at the point or points considered critical from a corrosion standpoint.

3. The inhibitor or agent is then injected from the surface at any time without disturbing the pumping cycle of the well.

4. It flows into the annulus at the depth previously determined through ports in the cross-over nipples.

Further information is given in the two bulletins enclosed with this letter.

If we can be of any further help to you or if you have any more questions or desire a specific quotation from us, please let us know as soon as possible. Due to the steel strike our orders have piled up, but we are making every effort to obtain steel and hope to be able to promise reasonable delivery dates in the near future.

Sam A. Gilliard

Gilliard Specialties Company

Gasoline Plant Piping

Below answers letter from Charles E. Webber, Sun Oil Company:

You ask about backwelding of screwed fittings, referring to Part 6 in the Gasoline Plant Piping series now running in The Petroleum Engineer.

Fig. 5 in this article shows the cost of backwelded screwed fittings, compared to the other type joints in the size range. It is the most expensive joint tabulated. On the basis of cost then, there is no reason for specifying backwelded screwed connections in a new installation.

Backwelding has frequently been resorted to for the purpose of sealing leaky screwed connections in existing installations. The weld alone is not strong enough to develop the full allowable working pressure of most small pipe. Backwelding is acceptable as a means of repairing high-temperature leaks in relatively low-pressure piping. A welded or flanged-type connection is definitely preferable in a high-pressure line or one subject to high external stress.

Your interest in these articles is appreciated. Let me know if I can be of additional help to you.

O. L. Lewis

C. F. Braun and Company

From Down Under

To The Petroleum Engineer:

Dear Sir:

May I take this opportunity in thanking you for the prompt and regular posting of your magazine to me over the past 3 years.

I have found your magazine (Combined Edition) extremely interesting. It is a pleasure for me to renew for a further 2 years.

Masewell D. Walker

Australasian Petroleum Company
Port Moresby, Papua
New Guinea

EVERY STEP
A SAFE STEP WITH BLAW-KNOX
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Everyone walks safely, confidently on Blaw-Knox Electroforged Steel Grating . . . the one-piece panels stay rigid and strong—without shimmy or shake—because there are no parts to work loose. Twisted cross bars provide sure footing under the most adverse conditions. For complete information, write for Bulletin 2365.
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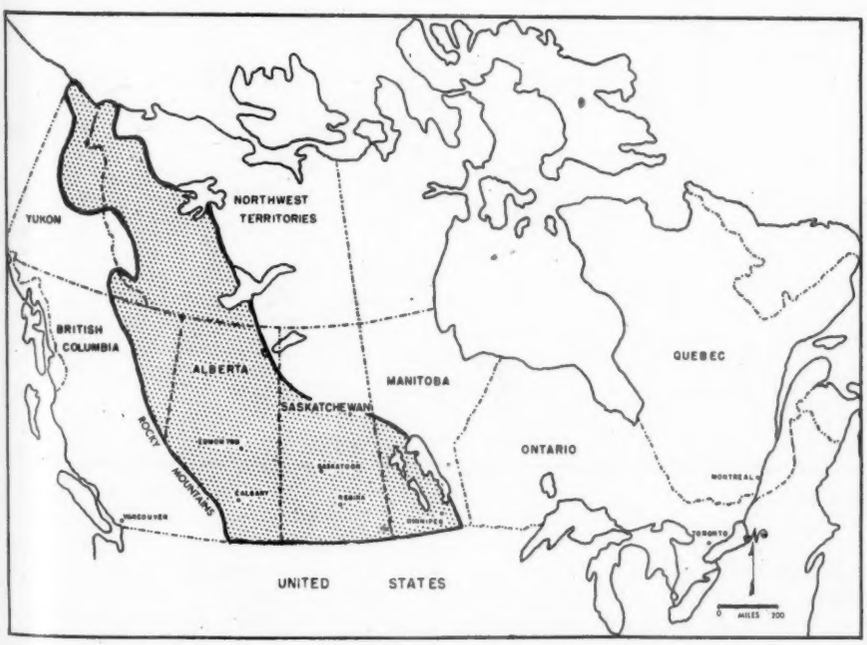
P 113.

Canadian Oil Panorama

Reserves and production are developing, pipe lines are increasing, and potentialities are infinite

JACK MENNEER*



Courtesy Canadian Bank of Commerce, Calgary, Canada.

FIG. 1. Western Canada sedimentary basin — potential oil and natural gas area — 800,000 sq miles.

EXCLUSIVE

TODAY Canada is one of the world's largest oil producers and this has been brought about in a short space of time — a matter of 5 years. The rapid expansion of a small producing oil and gas industry to the one of its present magnitude has required an enormous effort, the outlay of much capital, the overcoming of severe climatic operational problems, and above all, the fact that commercial hydrocarbon accumulations were available.

Although the major portion of both oil and gas production is in the Province of Alberta other areas are coming into the sphere of activity and these are in Saskatchewan, Manitoba, and British Columbia.

The year 1947 is the focal point of Canada's oil story, it is an historical marker in the long trail of Prairie oil events. In the early part of this century some commercial gas was produced in the Province of Alberta near Calgary. In the same area light oil was discovered and the Turner Valley field was eventu-

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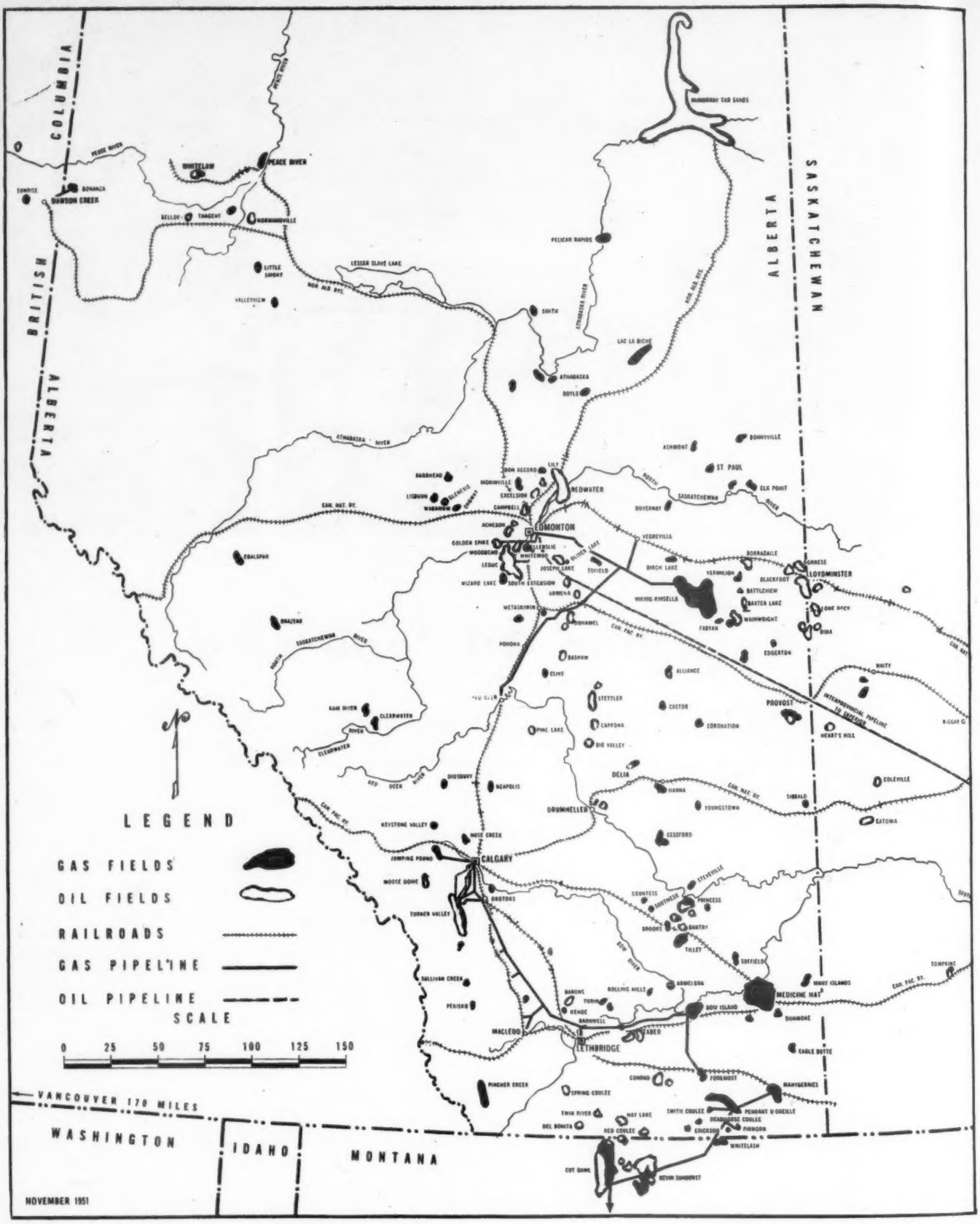


FIG. 2. OIL AND GAS FIELDS OF WESTERN CANADA.

Courtesy Canadian Bank of Commerce, Calgary, Canada.

ally developed. The occurrence of hydrocarbons in the locality spurred many in their search for other reservoirs, and after several years of almost futile exploration the Canadian formations were practically considered to be barren of additional hydrocarbons.

Imperial Oil Ltd on successfully producing Leduc No. 1 in 1947, and Redwater No. 1 in 1948, had revived and had proved beyond doubt that the search was not in vain.

Today Western Canada has a rapidly expanding oil industry and the future tends toward infinite oil potentialities.

From the 1930's and up to the Leduc discovery in 1947 some $50,000,000 had been spent in the search for oil. At the end of 1946 the monthly expenditure was in the order of $1,000,000 per month. The two major discoveries in

1947 and 1948 caused a sudden increase in exploratory work and by mid-1952 the amount appropriated by various operators was $4,500,000 per week for land purchases, exploration, and development. This shows a complete reversal of activity, and also by it may be judged the present financial impetus of the Canadian oil industry.

It is worthy of mention that Imperial Oil Ltd, a pioneer in the oil activities of Canada, had drilled 133 dry holes and had poured out $23,000,000 before their Leduc well was a successful oil producer.

Geology

The Western Canada Sedimentary Basin covers 800,000 sq miles of territory and adopts the shape of a pointing finger (See Fig. 1). Geological gradations are represented from Cambrian to Tertiary, and the lower Cretaceous, Upper Devonian, Middle Devonian — Silurian and Cambrian remain as the predominant formations.

Extensive three dimensional deposition occurred and the area was subjected to various phases of erosion, uplift, submergence, and marine invasion; strong influences of tectonic origin have also occurred. For example the foothills of the Canadian Rockies is an area that has been complicated largely by tectonic influences.

The disposition of the oil and gas does not presently conform to any specific pattern. At this early stage of the exploratory and development work it is hardly safe to generalize. An anomaly, and time may prove such to be incorrect, is that generally the oil on the western side of the basin is lighter than that from the eastern side. Another interesting geological feature is the Athabasca oil sand deposit, which is situated along the Athabasca river and near the town of McMurray, and covers an area of 30,000 sq miles.

The sand varies between 150—200 ft in thickness and the estimated recoverable oil reserves in place are believed to be 100 to 300 billion barrels, which is the largest petroleum reserve known to date. The oil sands are of Lower Cretaceous age and are underlain by the Upper Devonian lime. The overburden is a maximum of 100 ft and the oil is a viscous asphalt type. The economical production of this enormous petroleum bed has been under consideration for some time and large scale operations may be undertaken in the near future.

Three types of producing formations characterize the Canadian fields:

a. Reef
b. Anticlinal
c. Lenticular

Reef. This is a limestone, which may be dolomitic, and comprises two sections, namely the D2 and the D3. The limestone was laid down during the great upper Devonian reef forming period (See Fig. 5).

Anticlinal. This is of Mississippian age and it is probable that deposition extended to the east as far as the pre-Cambrian shield, that is prior to the extensive period of corrosion. (See Fig. 4).

A Leduc-Woodbend field separator and storage tank battery. Little water is presently produced and a D3 limestone produces with an average separator GOR of 600 cu ft per bbl. Gravity is 38 to 39 deg API.

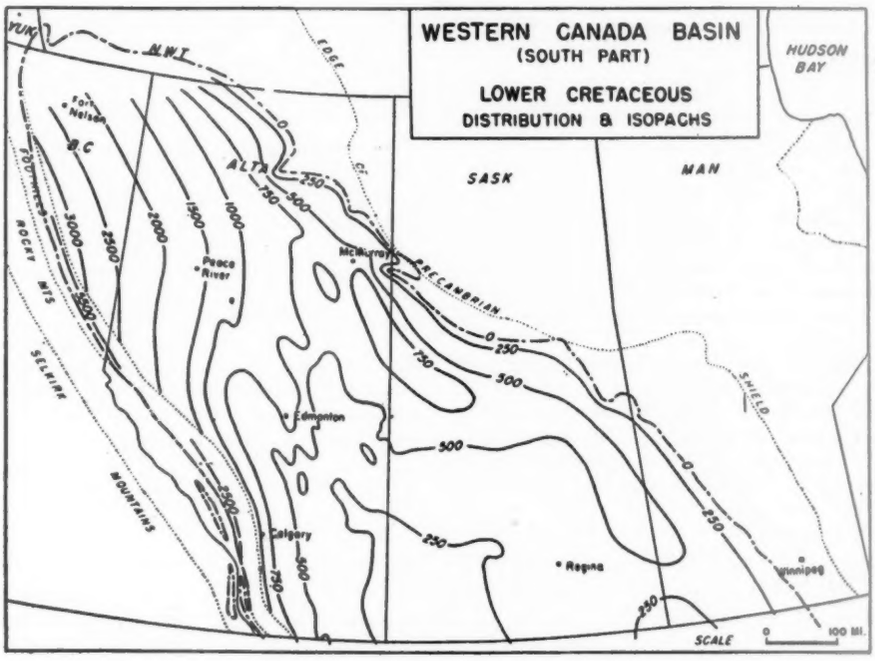
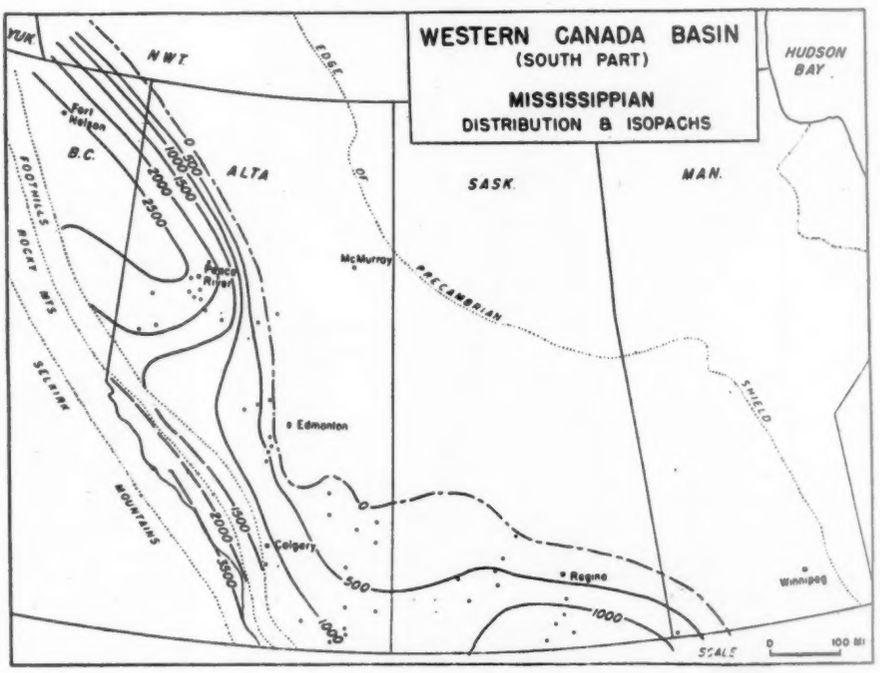


FIG. 3, above and FIG. 4, below.



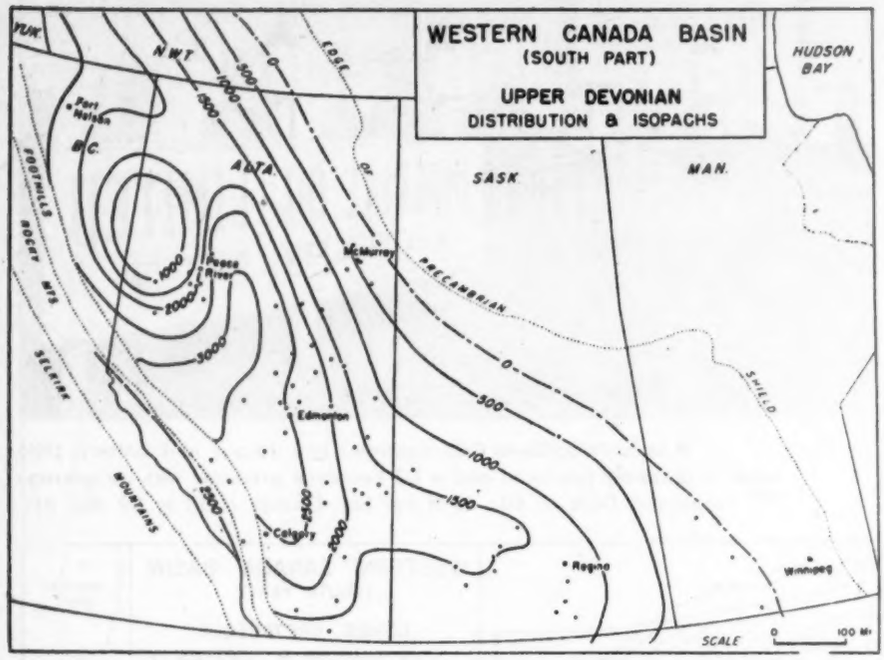


FIG. 5.

Lenticular. These comprise lenticular sand masses in shale formations and are generally of Lower Cretaceous age. The demarcation between the Lower and Upper Cretaceous is the Viking sand. (See Fig. 3).

A few examples of the particular types of field are as follows. Two reef types are the Leduc-Woodbend, which produces oil from the Devonian lime (D2 and D3), and the Redwater field, which is a similar producer in the D3. Two anticlinal types, and both being in the Mississippian limestone, are the oil producing Turner Valley field, and the Jumping Pound gas field. Two Lower Cretaceous oil producing fields are the Campbell, and the Lloydminister.

Climatic Problems

The geology offers many variations, and yet another Canadian variable is its climate. Canada is subjected to a long winter with low temperature weather. The average annual temperature for Calgary is 35 F. Sub-zero readings prevail throughout the basin for considerable periods and many operations are carried out with the thermometer at 60 below 0 F. Needless to say such conditions restrict efficiency of both humans and machines, and progress is somewhat hampered.

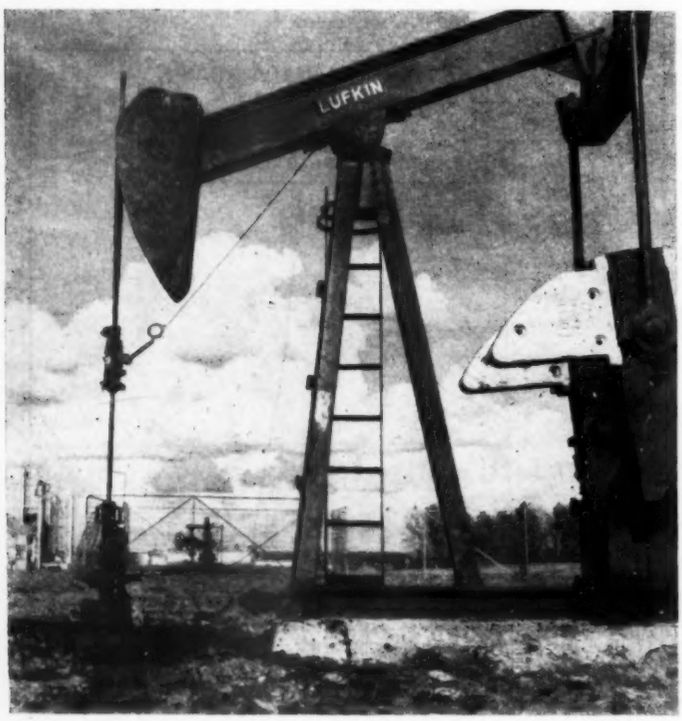
The summer is of comparatively short duration and this is a busy season for the Canadian oil operator. Many field arrangements have to be commenced and completed before the heavy snow falls and road transportation becomes perhaps even impossible. It is not uncommon to have temperatures in excess of 90 F during the summer and 60 below O in winter, so a wide variation in climate is experienced in this part of the world. Low temperatures create operational problems and some of these will be discussed.

As temperature decreases the tensile strength resistance to shock load decreases. In consequence when oilfield equipment is subjected to temperatures below about 40 deg below O there is a likelihood that embrittlement will occur, and on occasions a kelly or pumping beam has been shattered.

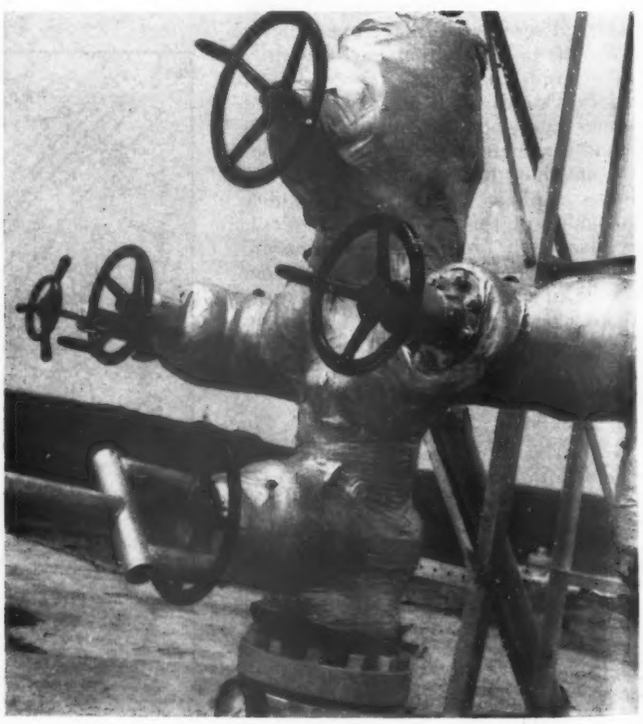
Lubrication is another difficulty experienced when operating in sub-zero weather, for example the gear box of mechanical equipment is presently suffering from the lack of a satisfactory low temperature oil. When intermittent operations are necessary, such as in production where 8 hr pumping and 16 hr idling occur the start-up period is a critical one and the lubrication of the surface equipment at this initial stage may be impaired.

Another point is that long hours of exposure may cause a lubricant to freeze. Electrical equipment that has a

Imperial Oil spent $23,000,000 and drilled 133 dry holes before its famous Leduc oil discovery. Production in the Leduc-Woodbend is from the D2 and D3 limestones, which are at approximately 5000 and 5300 ft respectively.



Shell's Jumping Pound discovery well, has insulated christmas tree for hydrate control. Hydrate formation in the tubing from this gas producing field is prevented by circulating "hot oil" in a closed system through the upper 3500 ft of the well.



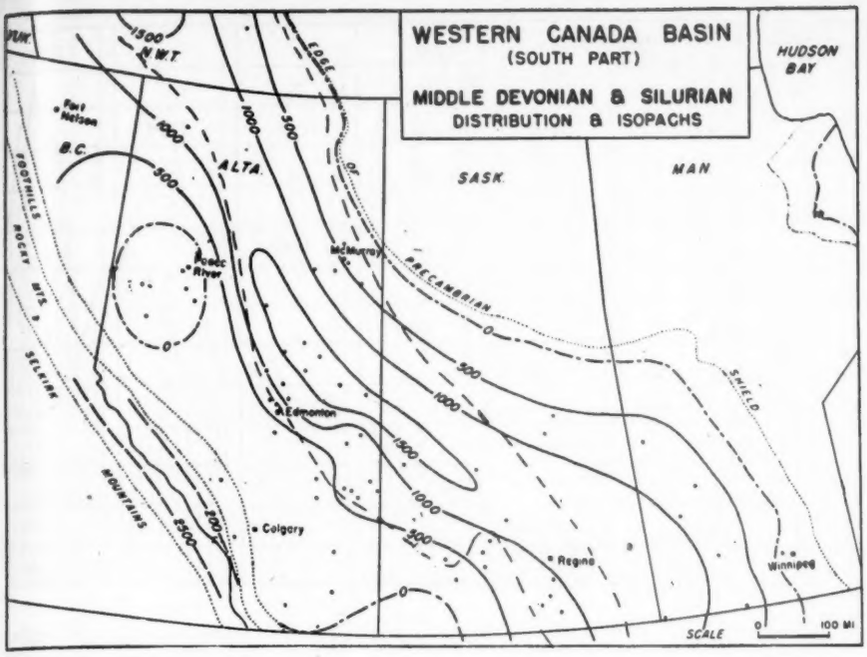


FIG. 6.

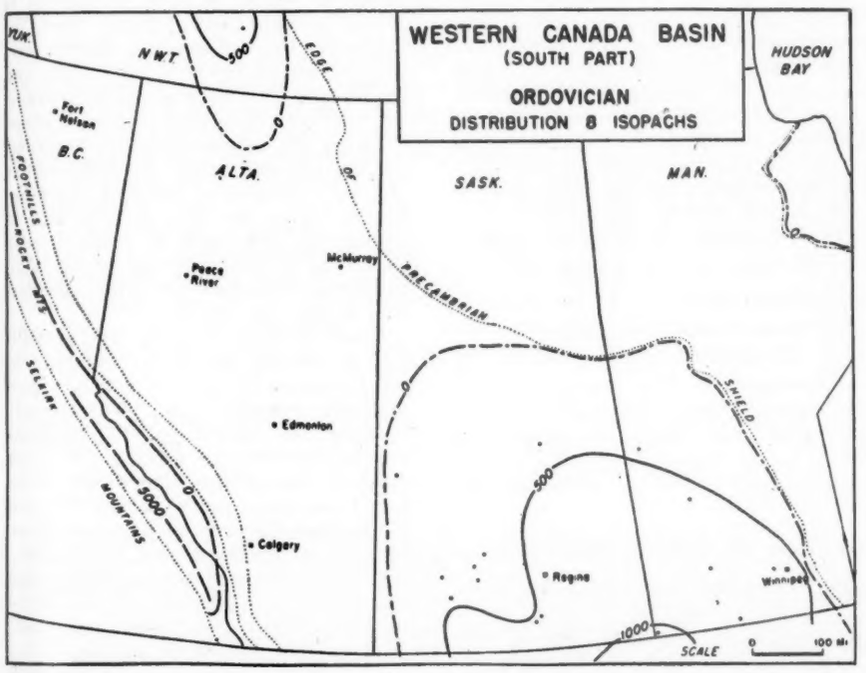


FIG. 7. (Figs. 3 to 7 were presented by J. B. Webb before American Association of Petroleum Geologists at Calgary, Canada, September, 1950.)

permanent-life-type oil presents another problem because the wide range of temperature, which in certain cases is from 60 deg below to 120 F, is too great for the oil that has been factory installed.

Welding operations are difficult in low temperature weather and often the weld will crack because of the chilling effect. Insulation wrapping has had some success in reducing the rapid heat losses.

The solution to many of the operational problems is one of supplying heat and if this can be accomplished the situation is usually well in hand. In the case of drilling, the complete drawworks, rig, and mud circulating system require winterization, this usually takes the form of having the complete set up as an enclosure, to which is supplied steam heat.

On the production side, hydrate prevention is an important consideration and special precautions are necessary. In addition to the down the hole treatment, flowlines have to be laid 4½ ft below the surface and special arrangements are made for metering devices.

Climatic problems are numerous in every phase of the oil field operations and every effort is made to overcome the limitations imposed by nature herself. The wide temperature range creates opposing conditions and it is often difficult to cater satisfactorily for the severe winter and then to operate in the summer without making extensive changes. Such requirements make operations expensive, but nevertheless progress continues with records being made in all spheres.

Exploration and Economic Development

As was stated earlier, the oil boom in Canada stems from the year 1947, and it is interesting to note that in the previous year, 1946, only 11 geophysical parties were operating. In 1947 the number had doubled and by the end of 1951 more than 155 crews were in the field—an increase of 14 times over a period of 5 years. The year 1952 will probably surpass this figure. Another trend that seems to be developing, due to the availability of leases in the region, is the inclination to explore farther north.

Exploration activities are being conducted over an area of 150,000,000 acres, and this is an increase of more than 7 times in the five year period.

More than 200 oil companies had invested an amount in excess of $200,000,000 during 1951 for exploration and development of petroleum in Western Canada, and 1952 is expected to receive an even greater financial expenditure than the record year of 1951. By referring to Table 1, it is observed that Canada's 1946 total oil and gas revenue was approximately $27,000,000 but by 1951 the figure had increased to approximately $144,000,000 or almost 500 per cent. (Fig. 8 shows the gross value of Alberta's crude oil).

The study of Canada in respect to a self sufficiency of oil presents another interesting picture. In 1946 the country was rated as 9.4 per cent self sufficient and in 1952 it is 33 per cent actual, and 50 per cent potential.

By early 1953 the potential rating is anticipated to be 75 per cent when 300,000 bbl oil per day will be produced "on balance". And in 1957 Canada should be 100 per cent self-sufficient "on balance" when the daily average production reaches 400,000 bbl. In order to accomplish self-sufficiency an additional billion dollars will have to be spent for the extension program, which is planned for completion by 1955. During the next 20 years, that is to 1972, the annual

TABLE 1. Comparisons of annual revenue (thousands of dollars).

Oil	1946	1947	1948	1949	1950	1951
Canada	$14,989	$19,575	$37,419	$61,118	$ 84,600*	$120,000*
Alberta	14,348	18,079	35,128	59,000	82,208	117,473
Natural Gas						
Canada	12,165	13,429	15,361	17,466	21,638	24,000*
Western Canada	7,246	7,815	7,620	8,582	11,099	12,400*
Total						
Canada	27,154	33,004	52,780	78,584	106,238*	144,000*

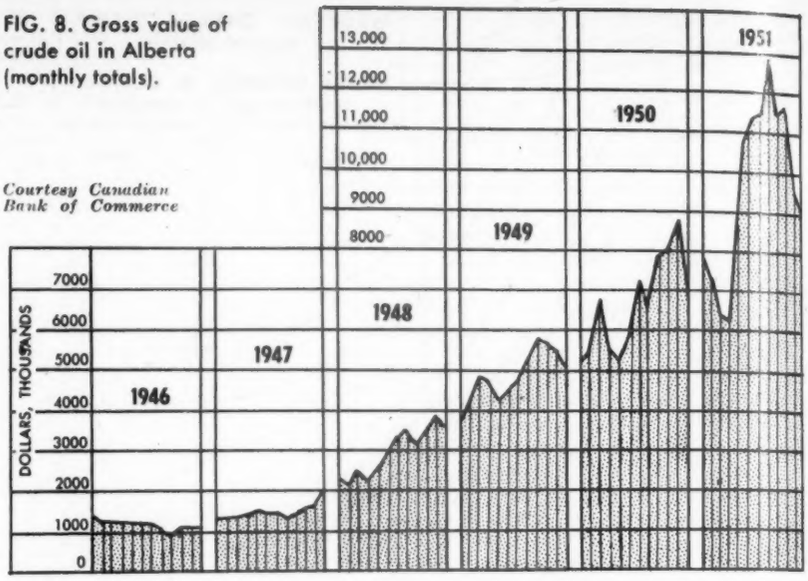
* Estimated

maximum efficient rate of withdrawal will probably average 7 per cent of the proved reserves. It is anticipated that discoveries will be 300,000,000 bbl oil per year over the next few years.

It is necessary to elaborate the expression "on balance", as this is the key to the Canadian-American oil situation. From an international standpoint the matter is complex—as are most international affairs—but every effort is being made by both countries to ensure that the two way free flow of oil across the boundary will occur so that each derives the maximum benefit within the limits of sound economics. It is geographically logical that the Prairie oil (Western Canada) be supplied to its own area and the Western U. S. A., and in reciprocation the U. S. A. should supplement from its eastern fields the demands of the Maritimes of Canada, which is under-supplied by Western Canada. This plan is already under way and full realization will enable Canada to reduce the importations of crude oil from the Gulf Coast and foreign countries in South America and the Middle East. By these measures Canada would become self-sufficient "on balance", because a large movement of trans-continental oil in Canada is not considered economically feasible. The Great Lakes freeze during the winter months and, of course, the Lake tankers are restricted and the installing of the necessary additional pipe lines is financially prohibitive. Thus "on balance" is the actual solution to the problem.

FIG. 8. Gross value of crude oil in Alberta (monthly totals).

Courtesy Canadian Bank of Commerce



Drilling

In line with the program for self sufficiency, footage drilled reached an all time high in Alberta during 1951 (see Fig. 9), and total footage per month ranged from a minimum of 329,000 in April to a maximum of 561,000 in July 1951. The Leduc-Woodbend was the most active drilling area throughout the year and the maximum footage drilled was 169,000 ft in the month of June, 1951. (As of June 1952, 50 drilling rigs were operating in the Leduc-Woodbend field). Drilling depths vary considerably, as may be expected in such a wide spread oil area as is the Canadian Sedimentary Basin. Producing wells are drilled from 1500 ft to 13,000 ft, and it can be summarized by saying that on the whole present drilling for productive pays in Western Canada requires 5000 ft wells.

Many problems confront the driller and the three most important are:

1. Winterization
2. Crooked hole
3. Anhydrite—Gyp mud control.

Winterization. The weather during the winter months necessitates special provision being made for combatting the sub-zero temperatures and unless such is done operations would be impossible. The mechanical difficulties have already been discussed under the heading of Climatic Problems. One phase of winter drilling operations is in the muskeg areas. Large tracts of boggy land called muskeg, particularly to the north, freeze over during the winter and it is then possible to transport drilling equipment over the areas. (During the summer months operations are not possible in the muskeg country and so a process of outward migration occurs before the thaw sets in, and in winter the trek back is commenced.) This type of in-and-out operation is an expensive procedure and adds considerably to the cost factor.

Crooked Hole. Another type of drilling is carried out in the foothills of the Canadian Rockies, which is a geologically complex area. The steeply dipping and over-thrusted formations are instrumental in making the worst crooked hole drilling conditions to be found anywhere in the world. To drill in the foothills is a costly proposition. an average 10,000 ft well takes $400,000, and all the technical knowledge and skill that can be applied are necessary to obtain a successful completion. A restrictive rate of penetration is essential in preventing a rapid deviation of the hole. Two earlier problems were the heaving-shale and frequent wash-out occurrences, but these were overcome by employing an oil emulsion mud.

Anhydrite Mud Control. Anhydrite and/or salt layers may be encountered at depths below 4800 ft and their presence requires special mud control, with attendant increased costs.

Cementing 7-in. casing in Imperial Oil, Ltd., well No. 97 Leduc-Woodbend field.

Production

The price per barrel for Alberta oil valves varies from $1.40 for a heavy crude up to $4.05 for the light such as the natural gasoline from the Foothills structures.

During the month of June, 1952, the Province of Alberta had 2700 oil wells that were capable of commercially producing, and of this number 2400 were operating. The Provincial daily average production for June, 1952, was approximately 190,000 bbl, which is a curtail-

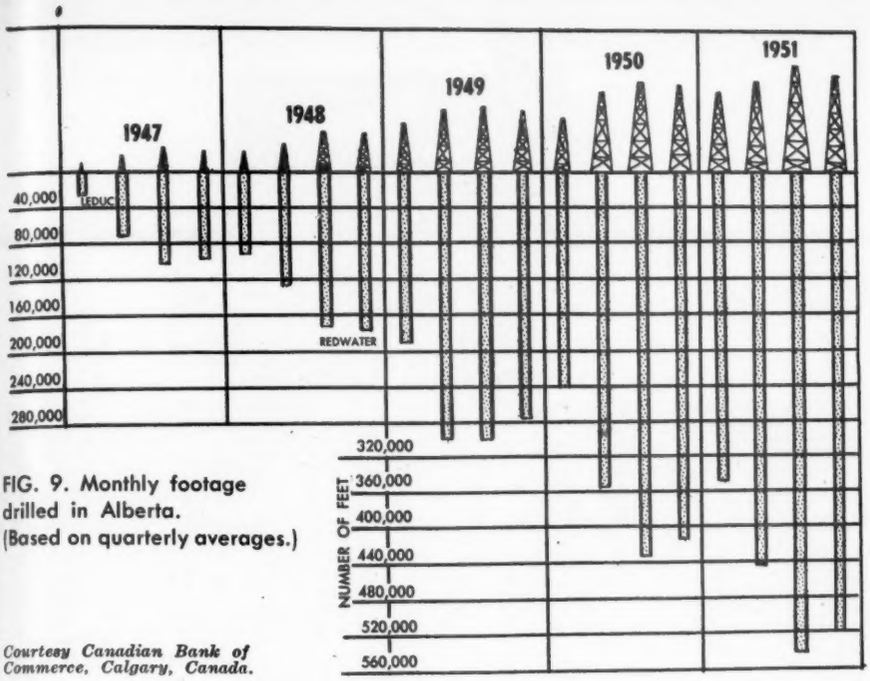


FIG. 9. Monthly footage drilled in Alberta. (Based on quarterly averages.)

Courtesy Canadian Bank of Commerce, Calgary, Canada.

ment on account of the restricted market outlets (see Fig. 10). The figure could be substantially increased to 270,000 bbl per day under sound conservation practices. For the month of August, 1952, the latter figure was probably some 286,600 bbl. The production of saleable gas is about 200,000,000 cu ft per day for Alberta.

The neighboring Province of Saskatchewan has approximately 200 producing wells of a heavy type crude, with a daily average production of 3500 bbl. As can be seen the concentration of Canadian oil production is presently confined to Alberta where an average well currently produces 80 bbl per day — a Saskatchewan well produces 20 bbl per day on an average basis.

The Petroleum and Natural Gas Conservation Board of Alberta is an authoritative government body and its function is as the title implies, that of hydrocarbon conservation. The production policy in the Province can be summarized as follows.

a. Proration.

Each well is assessed so that the rate of production conforms to the principle of obtaining maximum recoverable hydrocarbons, and this is arrived at by reservoir engineering studies.

b. Allowable.

The marketing limitations automatically restrict production and each month the refineries nominate acceptances for oil and gas, and the Conservation Board allocates the production from each field to meet the requirements.

Production problems can be classified under four headings.

1. Climatic
2. Hydrate
3. Hydrogen sulfide content
4. Salt water disposal.

Climatic. In addition to the production operational difficulties already discussed under climatic problems there is the imposition of curtailment that is caused by the winter conditions. The freezing of the Great Lakes and the resulting cessation of tankerage means that the spring production of 190,000 bbl per day will be curtailed to 90,000 per day. This is a serious reduction. The completion of the $80,000,000 Trans-Mountain pipe line to British Columbia will, however, alleviate the restriction by taking a minimum of 75,000 bbl per day.

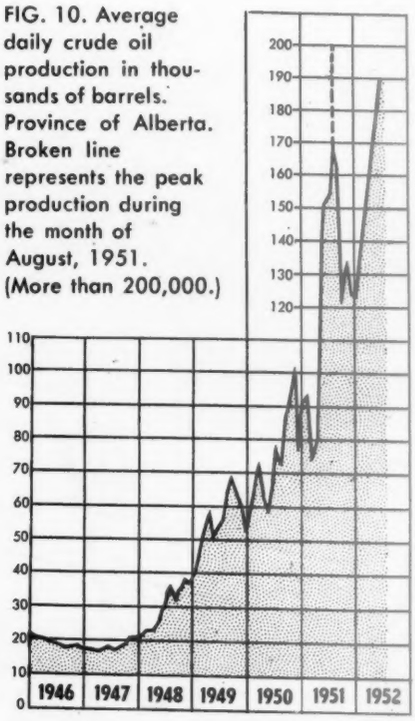
Hydrate. Large volume gas wells are likely to cause icing conditions in and around the well head equipment and unless appropriate measures are adopted production will be affected. This is particularly the case in Western Canadian gas wells where sub-zero weather aggravates the cycle of refrigeration. The addition of chemical "hydration reducers" to the effluent is used for overcoming the problem and the installation of electrical heaters down the well is being contemplated. One unusual and successful method in preventing hydration problems is that of circulating "hot oil" (100 F diesel oil) to a depth of 3500 ft in a well.

Hydrogen Sulfide. Some of the Canadian petroleum production is character-

Auger type cat-mounted bit developed for bush seismic operations in northern Alberta. Temperatures range as low as 60 degrees below zero. With only one main road available operations are conducted on bulldozed trails.

Courtesy Imperial Oil, Ltd.

FIG. 10. Average daily crude oil production in thousands of barrels. Province of Alberta. Broken line represents the peak production during the month of August, 1951. (More than 200,000.)



Line-up of four Cooper-Bessemer GMV, 10-cylinder, 1100 hp V-angle compressors installed in The East Ohio Gas Company's Robinson Station near North Canton, Ohio. Units compress gas from 400 pounds suction to 1,180 pounds discharge for underground storage and transmission to the company's marketing areas.

V ANGLE

Compressors

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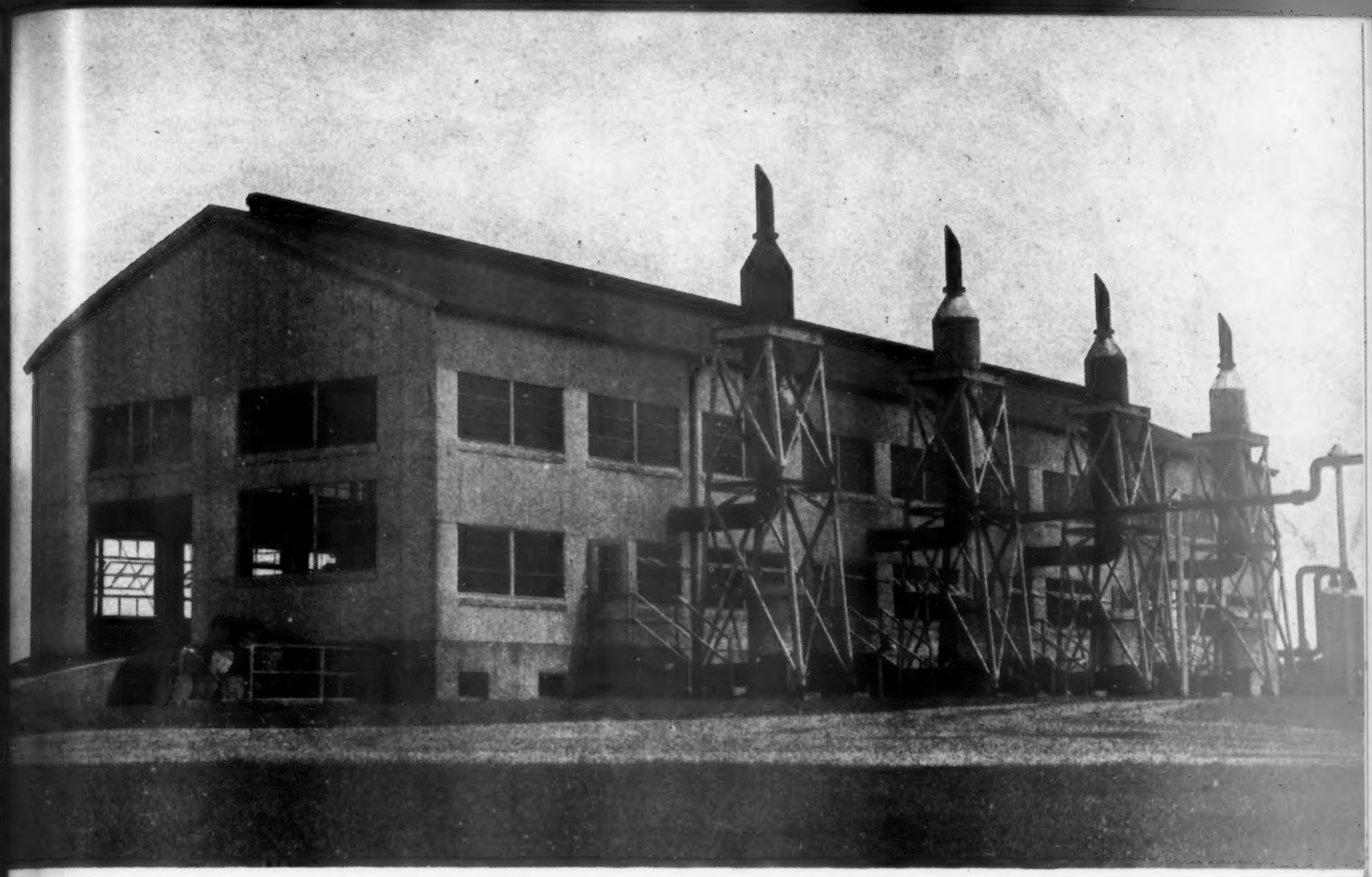

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The East Ohio Gas Company reports excellent low cost service and exceptional fuel economy from their 4-unit installation of GMV compressors at the Robinson Station, shown above. Here, gas from the Big Inch and West Virginia fields is either compressed for underground storage or further boosted in pressure to supply gas to the industrial Cleveland, Akron, Canton, and Youngstown areas.

During extreme cold weather peaks when the pipe line supply is insufficient, the gas is withdrawn from storage and boosted on to the same industrial areas.

The four GMV's installed in 1949 are 10-cylinder, 1100 hp turboflow units each with 5 compressor cylinders. The unique cylinder arrangement, utilizing each crankthrow, permits the engines to do three jobs at full load, boosting to market, pumping into storage, withdrawing from storage. Some 60 million cubic feet of gas is handled daily, from approximately 400 pounds suction to 1,180 pounds discharge.

Whether your plans call for complex compressor service, or the simplest kind of setup, you'll be ahead with Cooper-Bessemer V-angles. Check with the nearest Cooper-Bessemer office for the latest details.

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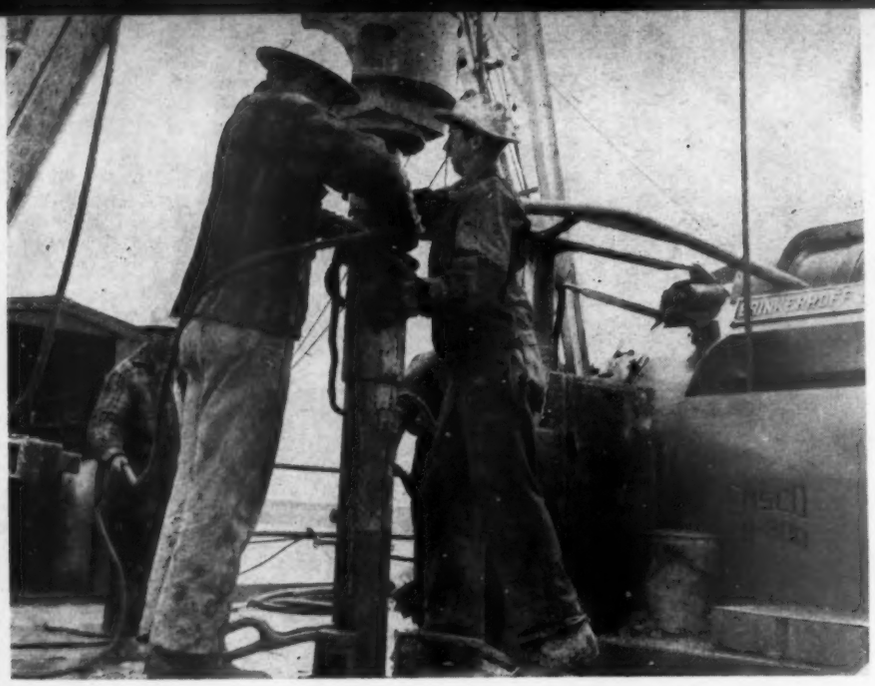


Crew makes connection for reaming out at 580 ft at Shell Unit 9 Jumping Pound.

ized by the presence of hydrogen sulfide, the content of which may vary from a fraction to 3.8 per cent. It should be mentioned, however, that Jumping Pound, Shell Oil of Canada, Ltd., is the first Canadian field to have a special plant for the commercial extraction of elemental sulfur from hydrocarbon production. (An excellent example of turning the objectionable into a most useful product, and particularly so as sulfur is in short supply).

Referring again to the original problem, the hydrogen sulfide behaves as usual with its corrosive antics, and the process for mitigation is by the injection of corrosion inhibitors. Another problem that has been remedied, by having an aluminum bottom, was the galvanic action occurring on the deck of production tanks, which was attributed to the deposition of scalings from the walls of the tank itself in conjunction with some minute traces of hydrogen sulfide sedimentation.

Salt Water Disposal. The production of saline water has not presently reached any serious proportion, but such occurs. Imperial Oil Ltd., produces in its Leduc-Woodbend operations about 2000 bbl of salt water per month. This field is situated in richly fertile and agricultural country and the provision of an injection well disposes of the salt water.

Transportation

It is axiomatic and an important theorem of economics that a petroleum product will serve no useful purpose unless it has a marketable outlet. Western Canadian oil presently has three supply areas, namely, West of the Rockies, East of the Rockies, and Eastern Canada (The Maritimes). (See Fig. 1). The three outlets present three phases of transportation. The route to the west is mountainous, and to the east of the Rockies it is of a localized nature, whereas to the extreme east, or the Maritimes, a distance of about 2500 miles the Great Lakes frozen in winter enter into the scene. The Sedimentary Basin of Western Canada has the oil and a part of the present operations is concerned with the expansion of transportation facilities. Taking Edmonton as the oil center, then from here, to the east extends the $90,000,000 Inter-Provincial pipe line to Superior on the Great Lakes and thence by tanker to the refinery at Sarnia. Another local line connects Edmonton and Calgary and for the West the Trans-Mountain Pipeline to British Columbia is under construction.

The transportation of natural gas out of the Province of Alberta still remains a controversial issue and a Provincial Government decision (as of July 1952) has not been reached on whether the recoverable gas reserves are sufficient to warrant the sale outside the provincial boundaries, with the exception of the present gas supply to the USA copper industries in Anaconda and Butte, Montana.

When considering a transportation system from a field point of view the availability of roads becomes an important item. Many of the Prairie locations are in isolated areas and in order to develop the field or, to wildcat it is quite often necessary for an oil company to construct its own roads. Naturally road building costs vary widely and it is difficult to stipulate. To give some idea of the position, however, eight miles of good gravelled road for a location west of Calgary cost $70,000, and one company had an expenditure of over half a million dollars for road construction and maintenance in Alberta and Saskatchewan during 1951.

Reserves and General Position

In 1947, prior to the Leduc discovery, Alberta's proved recoverable oil reserves were less than 100,000,000 bbl and in July 1952 they were placed at approximately 1.33 billion barrel — an increase of over 1200 per cent in five years. The estimated proved recoverable gas reserves from Alberta range from 6.8 to 8.6 trillion cubic feet. By combining proved, probable, and possible gas reserves an estimated figure of 13.7 trillion cubic feet of recoverable gas is postulated for the Province of Alberta. (8.6 proved, 2.5 probable, and 2.6 possible).

The original oil in place in proved areas in Alberta was approximately 3.3 billion barrel, and to date some 40 per cent has been recovered. The future rate of discovery is speculative, but based on geological evidence the possibilities are most favorable. Only a fraction of a vast sedimentary basin deposit has been subjected to the drilling bit, and this area of great possibility straddles from the Canadian-American International boundary right up to the Arctic, a distance of 1500 miles, and has a maximum width of nearly 800 miles in the south. Another region of probability is the foothills of the Canadian Rocky Mountain, which is a complex 600-mile long belt.

Although the major portion of both reserves and production is in the Province of Alberta there are other areas in Western Canada. The Province of Saskatchewan has an estimated proved recoverable oil reserve of 20,000,000 bbl, and the North West Territories has 30,000,000, (this is the Norman Wells field), and the Peace River Area has 10,000,000. This brings the total net proved recoverable oil reserves, in place, of Western Canada to the 1.4 billion barrel mark. The recent oil finds in the United States in both Dakota and Montana, which was in the Williston Basin and is believed to extend into the Canadian Provinces of Saskatchewan and Manitoba, has created a feeling of expectancy and hope for such petroleum possibilities across the Canadian border.

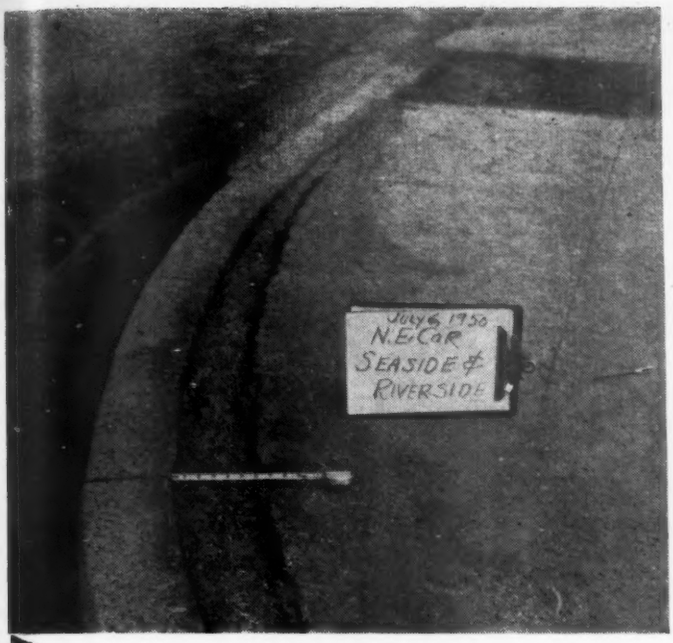
In summary and conclusion, the Canadian oil industry has aggressively and almost phenomenally expanded during the period 1947 to mid-1952. In addition to the remarkable progress to date its oil possibilities seem limitless. Vast areas remain that have to be subjected to seismic, and geological surveys, and exploratory drilling — thousands of square miles still have to be covered and thousands of feet have to be drilled in order to have some idea of the limits.

One serious drawback is the present steel shortage, which causes restrictive measures to be taken in all branches. This is emphasized by the suspended operation of 60 drilling rigs during the month of June 1952 because of the lack of tubular goods for well completions.

It is only a question of time before Western Canada has the appropriate market outlets for its petroleum products. In the light of this, and its past performance, Canada is today on the threshhold of a great and prosperous oil future.

Acknowledgment

The writer wishes to acknowledge the many kindnesses extended to him by the various oil companies during his recent visit to Canada. Particular thanks is expressed to the Imperial Oil Company Ltd., and the Shell Oil Company, and the Petroleum and Natural Gas Division of the Canadian Bank of Commerce. ★



Concretes, moving as a block, roll up black-top (asphalt) at corner of Seaside and Riverside.

Rolling up of asphalt and curb displacement at northeast corner of Santa Clara and Seaside.

Does Oil Withdrawal Cause Earthquakes?

Remedial measures to overcome subsidence in California may increase recovery from 50 to 100 per cent—investigation continues

RICHARD SNEDDON*

THE most recent development in the study of Long Beach subsidence is a somewhat embarrassing one for many of us who have had nothing whatever to do with it, but have, nonetheless, been stoutly supporting certain fundamental beliefs that on the basis of late findings may not be quite so fundamental after all. It is commonly contended by the "misinformed" man-on-the-street that the withdrawal of oil from underground reservoirs leaves voids into which the overburden finally tumbles, and we have an earthquake. We scientific chaps have scoffed at such a ridiculous notion and have argued that in the production of oil, the liquid is withdrawn from the interstices in the sand or limestone mass and that the porous structure remaining is quite compact and strong enough to support all that lies above it. Now, it looks as if the misinformed man-on-the-street wasn't too far off in his reasoning. In the case of unconsolidated sands, at least, the withdrawal of oil can cause earth movements.

When the Long Beach-Wilmington subsidence data are analyzed mathematically they fit into a somewhat disconcerting pattern. They indicate indeed, that following the withdrawal of oil from unconsolidated sands and the reduction of pressure within them, the pressure of the overburden does cause compaction in the sands and subsidence naturally follows. The entire problem, because of its economic aspects, has been the basis of intensive investigation for about eight years, and the recent work of Dr. G. D. McCann, director of the analysis laboratory at California Institute of Technology, and his co-worker Dr. C. H. Wilts, is of special interest to industry because it appears to establish pretty definitely that this particular subsidence can no longer be classed as abnormal. It is a perfectly rational occurrence which, of course, means that *it could happen in any oil field where oil is being withdrawn from unconsolidated or loosely compacted sands.*

As may be seen from the accompanying photos and charts, the surface effects of the earth movement are of major consequence. Actually, as of the middle of 1951, horizontal motion at the surface on Terminal Island was as high as 5¾ ft, and some recent measurements are over 6 ft. It can be well imagined what this does to pipe lines, railroads, building foundations, and other structures and machinery in which alignment of various elements is an important factor. Vertical motion also provides its concomitant of trouble. Large land areas on the mainland have already dropped as much as 11 ft below a 7-ft high tide, necessitating the erection of dikes, and the dry filling of low areas to keep surface facilities from being flooded. But most disturbing of all are the sub-surface motions and stresses that have been demonstrated in a shearing action that has rendered many wells inoperative and has threatened many more.

At the end of 1949, the most recent analysis was instigated by M. D. Hughes, then chief petroleum engineer for the Long Beach Harbor Board. This study was designed to establish, if possible, a method of mathematical analysis that would supplement current knowledge of subsidence causes and effects. At that time the available data consisted of vertical motion measurements for a few points; geological structure

*Pacific Coast editor.

EXCLUSIVE

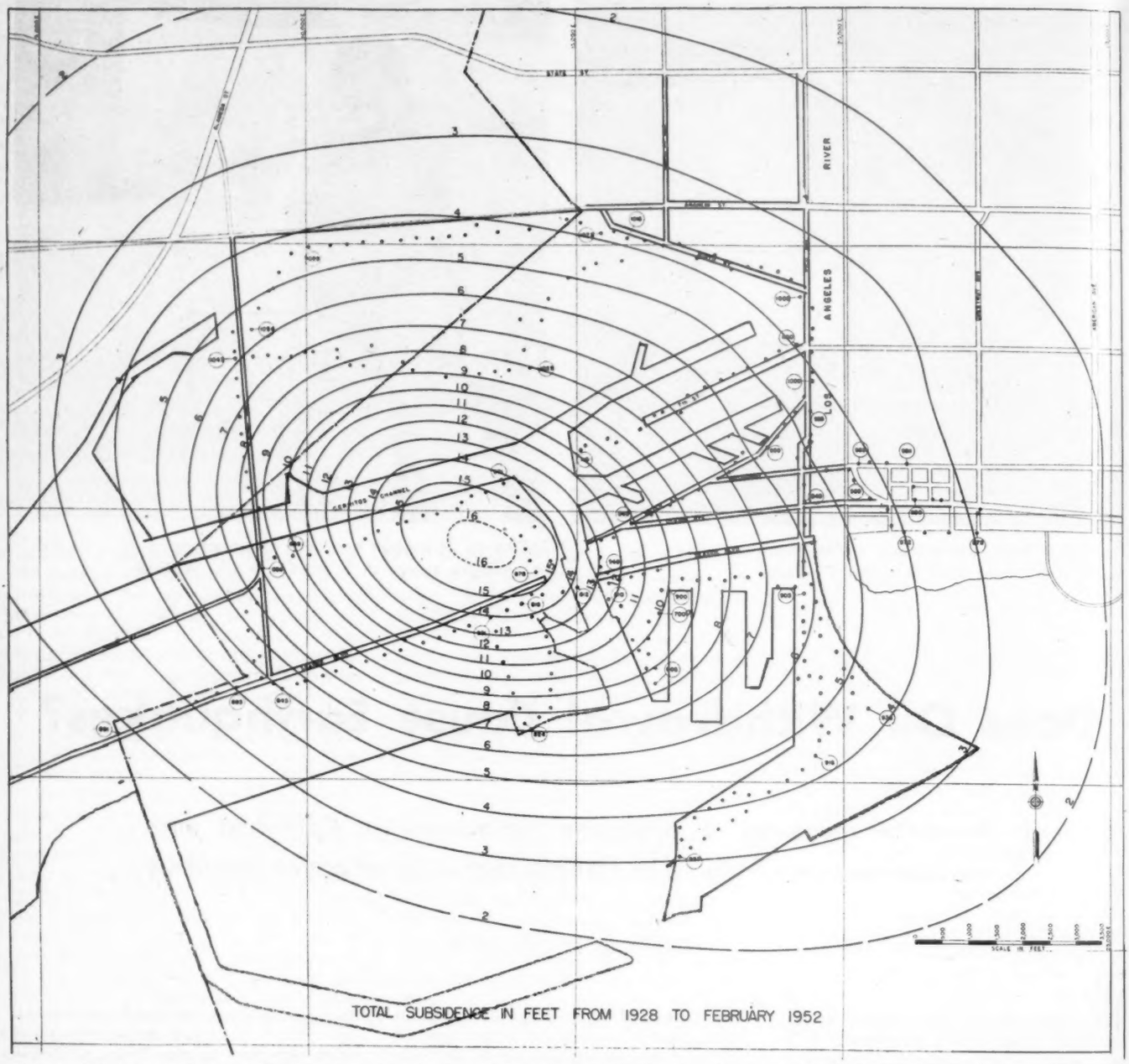


FIG. 1. Subsidence study of Harbor department, city of Long Beach, California, shows subsidence in feet from 1928 to 1952.

of the region involved, including the location and dimensions of producing strata; compaction figures developed by electro-magnetic measurement of pipe sections; and time history of the pressure drops in the oil producing zones as indicated by progressive pumping schedules. Nothing had been done on sub-soil analyses, and the necessary parameters on which to base actual stresses and movements in critical disturbances were not known.

The process employed was to develop from the measured and observed data a mathematical model that would describe the sub-surface phenomena and permit the calculation of future motion and sub-surface earth shearing stress concentrations. In other words, the plan was to build on what was known a complete mathematical model, ascribing sensible values to the important unknowns and refining each as logic dictated, until the whole pattern fitted the complexity of causes and effects within acceptable tolerances.

Examination of Fig. 1 will disclose the means by which calculations and actual measurements on the subsidence area could be correlated. A grid system (1000 ft to the grid), was superimposed on the map of the elliptically shaped subsidence area. As the subsidence is elliptical in form, the coordinate system was drawn with its origin at the center of subsidence and the two coordinate axes along the major and minor axes of the ellipse. The major axis traverses the area in a northwest-southeast direction, and the minor axis splits the bowl from northeast to southwest. It serves to locate points on any horizontal plane, and, of course, the two planes of greatest interest are the surface and an arbitrary level near the center of the oil sands which, for calculation purposes, is the assumed location of the analytical disturbance forces. The location of wells from which some 600 core samples were taken and tested to develop the relationship between measured and calculated values were within the mapped area of Fig. 1.

Important information regarding subsurface compaction was derived from collar counting studies. These involved the systematic measurement of the lengths of pipe sections to an accuracy of $\pm \frac{1}{8}$-in. by means of electro-magnetic instruments[1] lowered into the well bore by cable. If the pipe be seized by the soil, compaction of the surrounding earth compresses it. As the pipe resists compression and may be imperfectly bound to the soil, the measurements are an indication of the lower limits of soil compaction. Thus the results are in all probability low, but they do show that considerable compaction has taken place in certain oil bearing sands although very little can be observed elsewhere.

[1]Developed by Lane-Wells.

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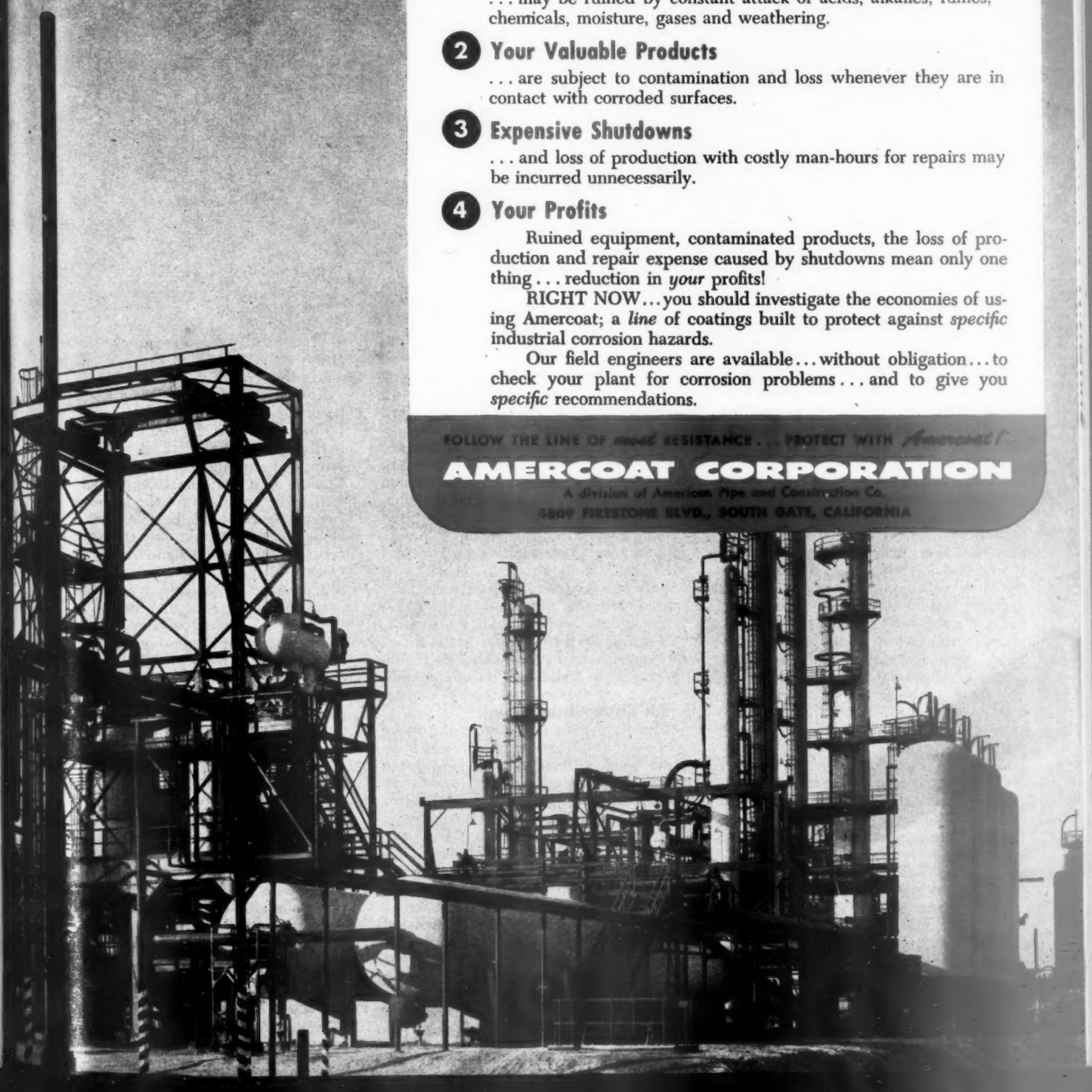


On Pier D, just south of El Enbarcadro is a confined arc of track mal-alignment.

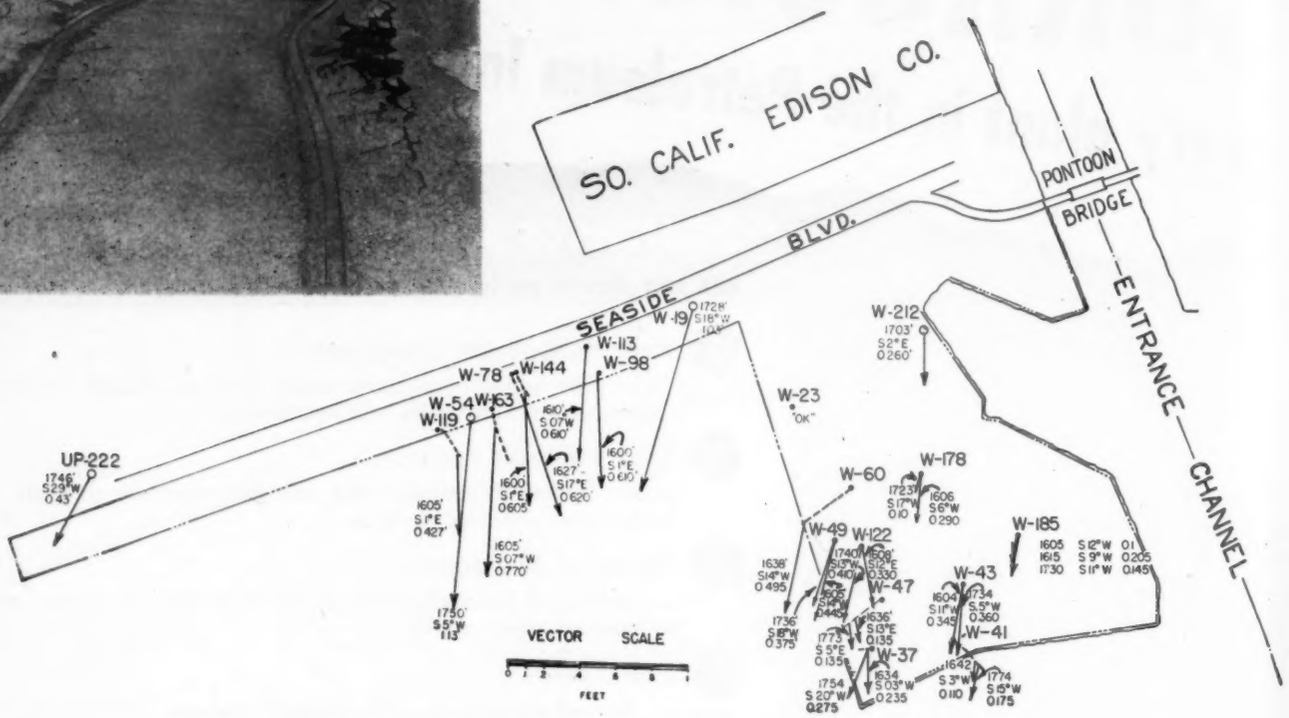


FIG. 2. Plot showing direction and amount of shear in Long Beach subsidence study.

These tests determined that most of the compaction associated with subsidence has taken place in the Tar, Ranger, and Upper Terminal zones, with some slight effect in the upper half of the Lower Terminal. This means that compaction is taking place in a vertical section of about 1200 to 1400 ft, centered at a depth of about 3000 ft. The maximum thickness of oil-bearing sands near the center of subsidence in this section is about 600 ft, and thence it tapers off in all directions. It is significant that the greatest subsidence takes place immediately over the greatest thickness of oil sand.

Earth motion is difficult to compute for a number of reasons, principal of which is the failure of the earth to act as an elastic material. Nonetheless, after divers consultations with various engineers and analysts relative to the physical properties of the soil, it was decided to adopt the concept of an elastic material of semi-infinite extent, and as nothing was known of the soil mechanics of the region, it was further decided that the mathematical model should be based on a uniform isotropic elastic medium of semi-infinite extent. With this agreed upon, it was also assumed for the purposes of the calculation that the withdrawal of oil from the deep lying strata caused internal stresses that are responsible for the movement of the surrounding earth.

Previously Dr. Nabor Carillo of Mexico City had developed an analytical solution for the surface motion of a uniform isotropic, semi-infinite, elastic medium under the action of a simple symmetrical set of sub-surface forces, known as a tension center. With this as a starter, a mathematical procedure was devised to permit calculation of surface and subsurface motions and stresses, not only for a number of such tension centers, but also for a general distribution of them such as might be required to simulate the effects of an oil pumping program. Investigation of a second mathematical hypothesis, consisting of a pair of equal vertical pressures, acting in opposite directions a short distance apart, and termed a "vertical pincer," showed that it did not at all fit the known data in the Long Beach subsidence area, while the "tension center" concept conformed in every respect within required limitations.

The significant effects are, of course, vertical and horizontal motion and horizontal shear stress, and the subsidence equations were consequently based on these with each being derived by two totally different methods to assure its correctness. The solutions show the manner in which vertical and horizontal surface motion varies with distance from the tension center; the vertical motion at several depths below the surface; the horizontal shear stress for a tension center; and the same for several depths below the surface. It is to be noted that the maximum stress increases steadily with depth and that the point of greatest stress comes closer to the vertical line above the tension center.

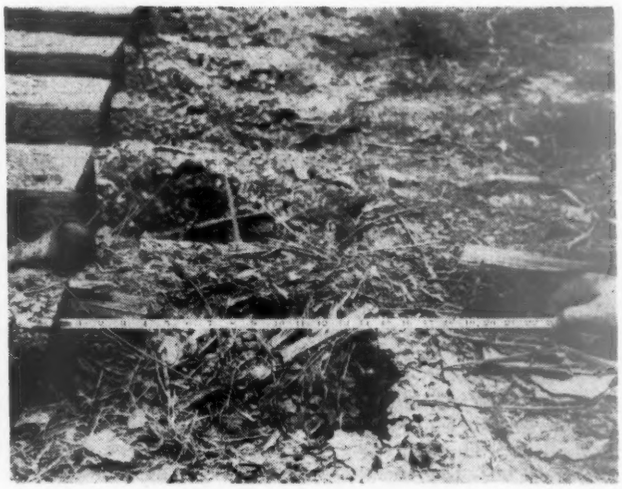
The entire investigational project may be divided into five separate sections as follows: 1. The accumulation of as much pertinent physical data as possible relating to subsidence in the area. 2. Choice of a mathematical model that would give solutions for the motions and stresses developed. 3. Employment of the model to derive unknown factors from actual measurements and other known values. 4. The development of a core test program to provide average elastic parameters for earth and soil shear resistance. 5. Testing of the model and setting up a method of predicting future conditions from proposed future oil pumping schedules.

Before discussing further the general progress of the investigation, it would perhaps be appropriate here to enlarge on the supplementary work that was carried on in connection with sections 4 and 5. It will be remembered that the mathematical analysis was begun without direct information on the basic parameters required to evaluate the properties of both the over-burden and the oil-bearing sands. Particularly necessary in the calculations were knowledge of the shear modulus of elasticity and data on shear strengths in the over-burden. Some 600 core samples were taken, and shear resistance data on these were plotted.

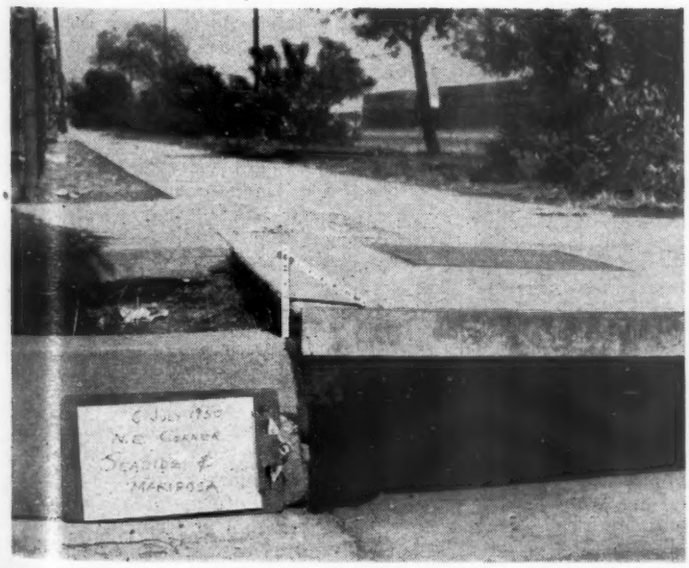
This shows how steel frame at transit shed on Pier A buckled from earth movement.

Roll up of blacktop adjacent to curb and break between the latter and the sidewalk.

Looking north from Seaside Boulevard track. Movement noted here was practically instantaneous.



Close up of track movement shows horizontal motion at maximum of 23 in. Ties and track moved bodily.



Horizontal motion moves sidewalk above the storm drain at corner of Seaside and Mariposa.

Stairway on passenger shed on dock side shows effect of compressive horizontal forces, all due to subsidence.

It was found that the shear modulus of elasticity (G) was remarkably uniform with little average increase for depths in excess of 1300 ft. In the horizontal shear calculations, an average value of 100,000 psi was used.

There is a significant correlation between the calculated horizontal shear stresses and the measured shear resistances. Comparison of these indicates that using the average shear modulus already referred to, the vertical pincers model produces shear stresses too low to cause failure in a system of the type involved; while the tension center model, on the other hand, provides shear stresses of expected magnitude, and they vary with depth in a manner similar to that of the shear strength data. Further examination of these data in the light of known occurrences and conditions shows that shear failures are caused primarily by the variation of shear resistance rather than the variation of sheer stress with depth as suggested by other investigators.

In the final testing of the model and setting up a basis for predicting future conditions on proposed withdrawal schedules, it is essential to define a rational distribution of disturbance forces from known conditions in the oil sands. The only pertinent data so far available on oil sand characteristics are location, thickness, and the oil pressure-drop-time history. The conversion of this information into a distribution of "disturbance forces" is admittedly an uncertain process requiring the imposition of certain assumptions relative to the properties of the oil bearing sands for which at the moment there are insufficient supporting data. To begin with, the three upper zones have been regarded as the total source of subsidence, as practically all of the measured compaction was found there. These three zones have a maximum oil sand thickness of 600 ft with a mean depth of about 3000 ft. This 3000 ft section of overburden normally requires about 5000 psi at the top of the oil bearing sands to support it. Before oil withdrawal started, the oil pressures were everywhere about 2500 psi, so it may be assumed that the other half of the support came from the compressive forces in the oil bearing sands.

When oil is removed from the producing zone, part of the resulting pressure drop is accounted for by added compression in the oil bearing sands due to compaction, and part is expressed in the added tensile forces developed by the overburden as it subsides. The "disturbance forces" effectively pulling down on the overburden may be regarded as the difference between the pressure drop and the increase in oil sand compressive force. The product of the pressure drop in psi (ΔP) times the total oil sand thickness in feet (T) at the well location gives a distribution function over the oil field that can be converted to an equivalent distribution of tension centers or other "disturbance forces" if one is prepared to make certain assumptions regarding the added force to which the oil sands are subjected during compaction.

It was considered reasonable to regard the overburden as being elastic in its gross behavior. Shear forces are being built up and maintained by the subsidence. To help establish one limit of the pressure drop effect on the oil bearing sands, they may be assumed to be plastic and readily compressible upon the withdrawal of oil. Thus the oil pressure drop is taken up completely by the overburden. The conversion of $\Delta P \times T$ to appropriate tension centers on the basis of this assumption formed an important step in the mathematical analysis.

Another limit was defined by giving a reasonably high value to the compressive modulus of the oil bearing sands and then calculating the load distribution between the oil sands and the overburden. In this instance a trial and error type of solution is required, assuming first a specific distribution of disturbance forces and then calculating the vertical subsidence at the top of the sand member. From this, the compaction and the resulting load borne by the oil sands can be determined. The compaction force distribution over the area is then substracted from the assumed "disturbance force" distribution, and the result should be the known pressure drop distribution. Successive series of such calculations are carried out for numerous cases until the results actually do conform to the known pressure drop.

Needless to say, these and other calculations that formed an important part of the total analyses were the subject of all sorts of mathematical tests and conjecturings. Preliminary calculations of the type just described placed the shear modulus of elasticity rather low to fit the subsidence pattern but of the same order of magnitude as was indicated by the core sample tests. It became obvious, however, that before such calculations could be justified on a large scale, certain additional work would have to be done; for example, a comprehensive core sample study of the oil-bearing sands and a general analysis to correlate the important characteristics of the distribution ($\Delta P \times T$) with those of the developing bowl of subsidence. It was further believed that the entire investigation would be well advanced by a comparison of the time history of the developing bowl of subsidence with that directly calculated from the time history of the distribution ($\Delta P \times T$); an additional comparison of the differences between actual subsidence and that indicated by the distributions ($\Delta P \times T$) over all parts of the bowl for each year .... this to locate any regions of marked divergence that might be due to large variations in soil properties with location; and, finally, a search for evidence of any important non-linear effects.

The pursuit of this phase of the problem necessitates a great many subsidence calculations from the given distributions, but it is practicable if definite conversion from the $\Delta P \times T$ data to the tension distribution is applied. For this purpose the pressure drop was converted into a distribution of oil bearing sands with their corresponding per unit area pressure drop being converted into an equivalent volume of tension centers. After calculations had been made with corrected data covering the years from 1945 to 1951 inclusive, there were also compiled for analysis, tabulations of proposed $\Delta P \times T$ distributions for 1952 and two possible ultimate pumping schedules.

Profiles of the surface subsidence for the years 1945 through 1951, taken from contour plots of actual measurements, were prepared. Then, using the conversion formulas already established, vertical subsidences were calculated for each year for a large number of points throughout the bowl, a sufficiently large number, indeed, to locate contours accurately. Using the 100,000 psi shear elasticity modulus, a complete plot was then made for all locations of the calculated versus the measured subsidence, and it was observed that they are all quite close to a single mean curve. The maximum deviation is about 25 per cent with most of the points falling within 10 per cent of the curve. This was true for all points calculated, and is of the utmost importance as it shows that regardless of location or time there is so far an essentially single valued relationship between the calculated and measured results as defined by the single mean curve.

The non-linear character of this curve is especially to be noted. For measured deflections of 6 to 10 ft there is a decided increase in the ratio of measured to calculated subsidence, regardless of location or time. There are a number of possible reasons for this, and the authors of the report recommend that these be the subject of further studies, and that more information on soil properties be developed for that purpose. It is suggested that some of the important non-linearities may be in the compact oil sands, others may be in the overburden.

Predictions Possible

As a result of the analysis, it has been established that there is a direct correlation between the development of the bowl of subsidence and the increase in the distribution $\cdot (\Delta P \times T)$, which is essentially independent of location and time. There is, consequently, no indication of any marked change in soil properties with horizontal location. In consequence, the authors contend that if the non-linear character of the phenomena can be expressed by some more tangible process than the empirical method that produced the average curve employed here, it will be possible to predict future developments with reasonable certainty. For the present, the average curve must be extrapolated from considerations of significant events as they have so far occurred and the probable variation in soil property trend with further compaction of the oil sands. It is to be noted, however, that some of the extrapolations made with respect to effects in 1952 have been fairly accurately fulfilled.

Remarkable conformability was noted between the actual and calculated subsidence, and as the position of the calculated bowls of subsidence with respect to the coordinate axes depends on the location and character of the distributions

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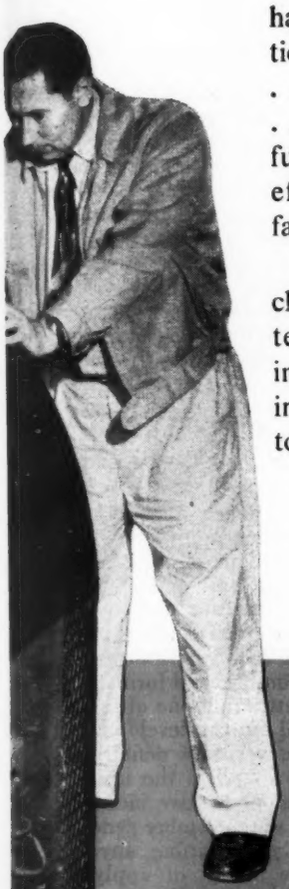

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● E-M craftsmen welding the fabricated steel frame for one of these pumping motors. Note extra-heavy steel plate and sections which give proper bearing support in bracket-type design.

($\Delta P \times T$), the coincidence of the calculated with the actual leaves little doubt that the reduction of oil pressure in the producing sands is the major cause of the subsidence. The procedure employed thus offers the best method of directly calculating prospective motions and stresses from a given set of $\Delta P \times T$ data. In summary, it is as follows: Expected bowls of vertical surface motion are calculated from the distribution ($\Delta P \times T$) and adjusted by the average curve. With an estimate of vertical subsidence thus available, the necessary tension centers distribution required for an accurate direct fit of this subsidence is next determined. This tension center distribution is then used for the calculation of additional motions and stresses, e.g., horizontal surface motion and horizontal shear stress.

The mathematical model, as already suggested, is subject to additional study, but there is mounting evidence that it represents a reasonably accurate analysis of the subsidence conditions. Calculations for the revised $\Delta P \times T$ data indicate that the maximum subsidence is about 24 ft and that the continued withdrawal of oil may, under present conditions, extend the subsidence area to a considerable extent in a southeasterly direction. Calculated horizontal surface motions for two proposed pumping schedules show that on the southwest side of the minor axis of the present bowl, horizontal motions up to approximately 9.5 ft are to be expected.

Subsurface horizontal shear calculations are most important because excessive shear stresses have expressed themselves in casing failures, and, after all, loss of production is what brings the entire analysis about. So far, the amount of relative motion in each instance has been of the order of a few inches to one foot, with a total maximum accumulated motion at any point of about three feet in the worst case. Slippages of this type increase vertical surface subsidence, and decrease the horizontal surface motions and subsurface shear stresses in the immediate vicinity. Some of the projections show that in large areas, shear stresses in excess of shear resistance are inevitable. The only consoling factor, and it constitutes very doubtful consolation, is that the ultimate picture may be ameliorated by intermediary failures. To what extent these may be averted by extraordinary remedial measures remains to be seen.

Meantime, the petroleum division of the Long Beach Harbor Department has undertaken a dual project designed (a) to counteract compaction and hence prevent further subsidence by replacing the fluid withdrawn from oil bearing sands with water; and (b) to minimize future reduction in oil yield by repressuring the sands with water and gas. This program also makes it mandatory that all future off-shore wells be operated under some approved form of pressure maintenance to protect city properties against subsidence hazards. Preliminary experiments indicate that water flooding of the upper zones will increase ultimate oil recovery from 50 to 100 per cent.

Conclusion

The entire subsidence problem is a serious one, indeed, and it is fortunate that the Long Beach city and harbor authorities have recognized the fact and have taken adequate steps to minimize its effects both now and in the future. The most significant discovery of this latest mathematical analysis, that subsidence is caused by withdrawal of oil from an unconsolidated formation, translates the matter into one of much wider interest, and future developments both in the more accurate definition of involved factors and in the institution of remedial and preventive measures, will no doubt be watched more generally and more intently. Meantime, anyone interested in the modus of applying pure mathematics to the solution of a complex problem in production engineering will find it stimulating to study the process employed in this case a little more intimately and, of course, intelligently than it has been done here.

Reference

"A Mathematical Analysis of the Subsidence in the Long Beach-San Pedro Area," by G. D. McCann, Professor of Electrical Engineering and C. H. Wilts, Assistant Professor of Applied Mechanics, California Institute of Technology, Pasadena, California, November, 1951.

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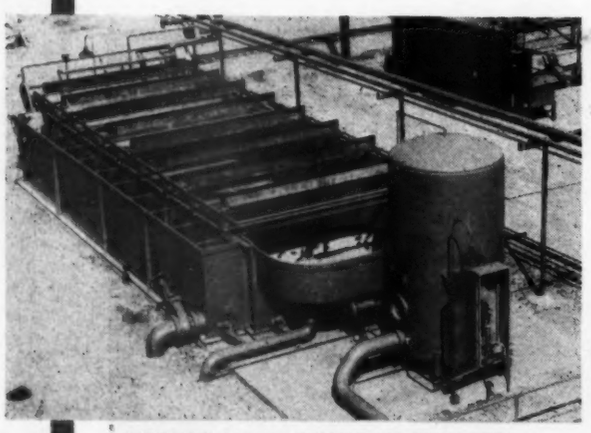
Oil-field brine "A"	40.0	5.0
Oil-field brine "B"	300 to 500	1.0 to 6.0



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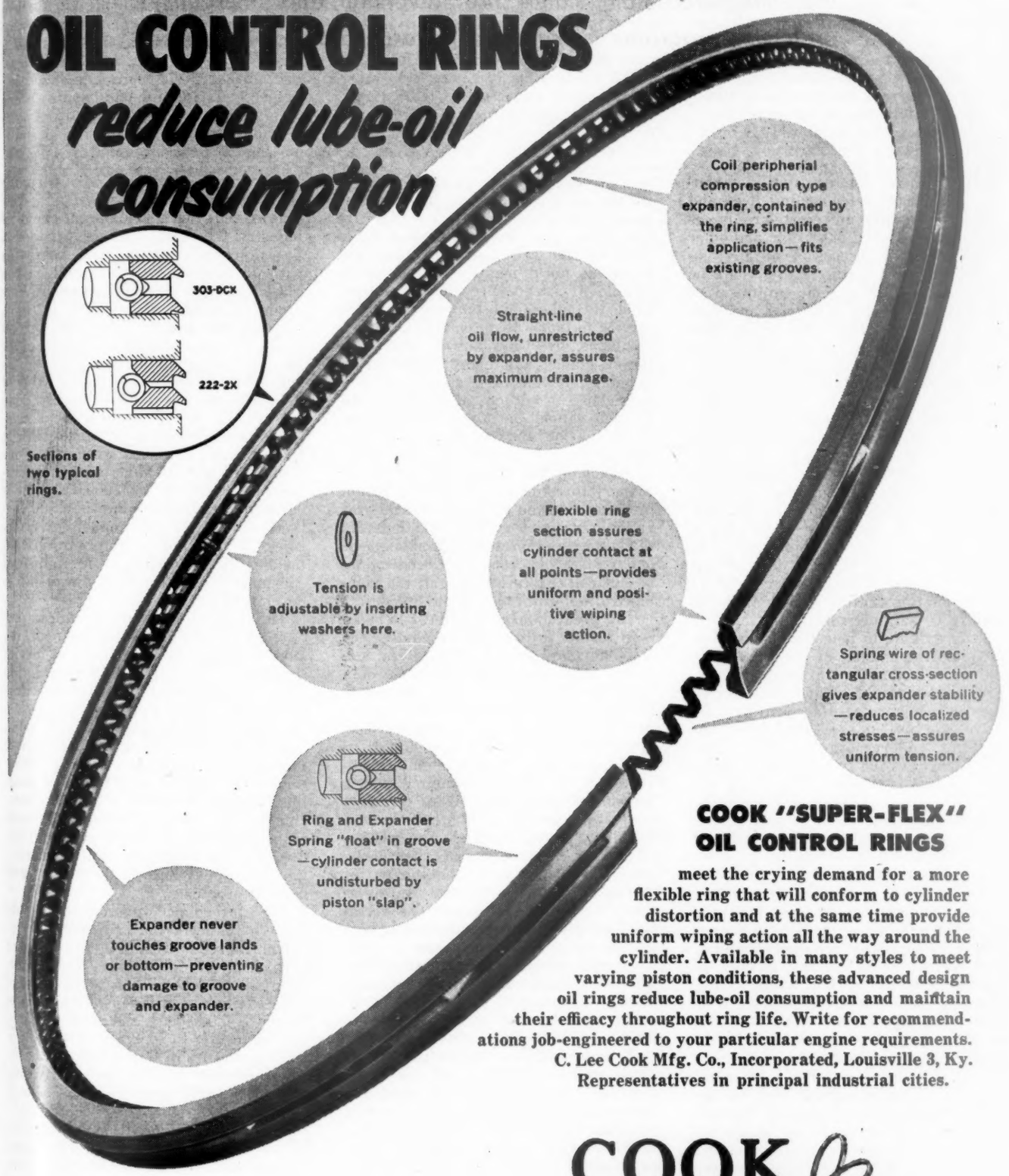

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Well-integrated maintenance, fire-prevention, and emergency protection programs will cut down hazards to our oil resources

MATHEW W. BRAIDECH*

OUR primary interest at this conference is one of safeguarding lives and conserving natural and created resources against loss by fire, explosion, and other related perils. Discussion of any important subject in this regard would be incomplete without some appraisal of its position in our industrial and economic makeup. There has never been a time when the petroleum industry has been of such tremendous importance to the present and future welfare of our respective countries, and, in particular, to our way of life. Petroleum and its array of multiple products are currently playing a most predominant and indispensable role in our dual civilian and military economy. In supplementing the important needs of our friends and neighbors, this industry is playing a most decisive part in global strategy. It can therefore be agreed that an extended discussion on petroleum and its safety in this critical period of world history is certainly timely.

It is striking to note that in the past 40 years the amount of energy used in the United States, for example, has approximately doubled, and that almost the entire increase was provided by petroleum and its associated twin, natural gas. Today, more than 60 per cent of all energy used in the United States and Canada is obtained from these two extensive sources. Although our population is only 6 per cent of that of the world, our joint production, by virtue of this abundant power supply, is more than equal to the rest of the world put together. The real significance of petroleum's chemical muscles is made all the more outstanding when its total energy output is popularly reported (Oil For The World: Schackne and Drake) as equivalent to the work of about 22 billion able-bodied workers laboring 8 hr a day, five days a week—which exceeds by about 10 times the total number of people in the entire world.

Originally, the importance of petroleum was almost entirely due to the gradual development and steady increasing use of the internal combustion engine. Many of us may recall when our appreciation of the petroleum industry was primarily through kerosine lamps and gas buggies. The expansive growth in the past decade has been almost breath-taking—we are not ordinarily aware that there are in operation today over 400,000 wells and more than 400 refineries, not to mention the thousands of miles of cross-country pipe lines, hundreds of tankers and tank trucks which service millions of automobiles, trucks, airplanes, diesel locomotives, stationary power plants, and many power-driven farming implements, in addition to providing fuel to millions of dwellings and to such valued consumers as our merchant marine and naval vessels. This Herculean task requires an investment approaching $10 billion ($2 billion in refinery investment with a $6½ billion product value and $1½ billion in natural gas operations)—making this industry the largest and most important segment of our American economy, exceeded only by agriculture, railroads, and the combined divisions of our public utilities.

This great industry continues to make even further inroads into our daily lives—its horizons are broadening and the end is nowhere in sight. Because of a strong combination of research-mindedness and business acumen, its original rule-of-thumb, empirical technology has gradually developed into a scientific art. This outstanding readiness to develop and adopt new ideas is bringing about a marked transformation from orthodox oil refining into modern production of so-called "petrochemicals". The refinery oil and gas end-products and their derivatives are now low-cost sources of thousands of formerly rare and relatively expensive chemicals. The versatility of this fast expanding appendage of the old petroleum industry is indicated by the listing of such off-shoot synthetic products as rubber, plastics, fibers, solvents and antifreezes, detergents and wetting agents, hydraulic fluids and lubricant additives, jet-engine fuels, insecticides and agricultural pesticides, soil conditioners and fertilizers, and medicants ranging from antibiotic miracle drugs to substitute blood plasma (polyvinylpyrolidone), along with thousands of other organic chemicals, such as glycerine, toluene, and, more recently, acetylene.

This chemical phase of the industry was accelerated to leaps and bounds by low-cost supplies of natural gas brought about by the long-distance transmission pipe lines. In comparison, these petroleum-derived chemicals are currently showing an annual increase at a rate that exceeds that of the parent chemical industry. The total tonnage production has practically skyrocketed beginning with 75 tons of antifreeze and carbon black in 1925, 5,000,000 tons of hundreds of additional products in 1950, with an increase to 7,500,000 tons in 1951, having a marketing value of $2 billion—the prediction for 1962 is 32,000,000 tons, with an estimated value of $7½ billion. The field is highly competitive, 20 major petrochemical companies are already in existence, with at least 15 more newcomers reported—one principal operator alone has an investment approaching $500,000,000, and is currently producing more than 300 synthetic chemicals in commercial quantities. A new policy of organizational teaming-up of producer and industrial consumer groups for joint ownership is developing in this field.

This transition toward chemical production is outwardly apparent at the sites of many of our modern refineries through the appearance of a bewildering array of multi-storied distillation towers and varied shapes and forms of processing vessels and storage tanks. In addition to the conventional fractionation, thermal, and catalytic cracking operations employed for production of gasoline, naphtha, kerosine, lube oil, waxes, and asphalt, such specialized and complex operations as polymerization, hydrogenation, alkylation, and isomerization are appearing on the scene with new fire problems.

The foregoing dissertation should serve to indicate the criticality of our petroleum refineries and their associated petrochemical operations. Their heavy investments with highly concentrated values (some installations are known to exceed $50,000,000) and their continuous exposure to operations handling large quantities of flammable materials, whose inherent hazards are greatly augmented by high pressure and elevated temperatures (including corrosion), present a picture of extreme vulnerability to damage by fire and explosion. Among underwriting circles the severe inherent explosion hazard is regarded almost inseparable from fire to the extent than an explosion clause is usually mandatory on all oil insurance contracts. In oil process areas, the product is usually at temperatures above the flash

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point and often above its ignition temperature, so that any leak or break is likely to result in fire or explosion. Cases are on record where even small and originally insignificant, uncontrolled fires have been known to have rapidly developed into calamitous proportions with great damage.

The fire records of the American Petroleum Institute indicate a present-day annual occurrence of some 1100 fires (including 300 refinery, 285 terminal service stations, and 175 oil well fires) with a loss of about $7,000,000 on insurable values of $7 billion. The comparative frequency of fires for various operations is given as 190 fires/100 refineries, 8.6/100 gasoline recovery plants, and for tank farms and tanker-barges 1.8 and 1.6/100, respectively. The steadily increasing loss potential is shown in the past 15-year period, where the losses have gradually grown from a low of $600,000 (reporting not complete prior to 1946) to a high of $11 million per year, while the annual insurable values increased from about $1 billion to a high of $7 billion (1950). These industry-reported losses do not necessarily correspond with those paid out by the insurance groups.

The foregoing record of steadily improved fire safety in the face of continuous changes, which are constantly augmenting the associated hazards, cannot be denied as being strikingly outstanding. Credit is due to the advanced engineering design and the use of improved materials of construction, and the progressive incorporation of the required fire safety measures in plant layout and operating programs. A major factor in the increased safety has been the close technical supervision in operation and the constant vigilance provided by automatic instrumentation in the control of fluid flow, pressure, and temperature; and, not to the least extent, the well-integrated maintenance, fire prevention and emergency protection programs.

It is of interest to note, in comparative contrast, that flammable gases and liquids account for approximately 9000 explosions and more than 55,000 fires (or about 10 per cent of 650,000 total fires) experienced annually, with an average yearly loss of about $45,000,000. The loss of life through such mishaps alone amounts to nearly 4000 persons. The records also show that the number of fires and explosions in industry (due to flammables) is about double that encountered with ordinary combustibles. It is of particular interest to note that only 3 per cent of the total number of fires (about 2000) occurred in chemical plants (who are among the largest handlers of flammable liquids and gases). These figures should serve to further emphasize the excellent record of the petroleum industry and the important role of its extensive safety program.

It should not be assumed that this remarkable development of technological proficiency occurred without heart-breaking problems and brain-straining handicaps. Various historic accounts are on record that tell of many rugged trials and tribulations. A typical example of such chance-taking pioneering is given in the following account by Dr. Gustav Egloff, research director of Universal Oil Products of Chicago, wherein he reflects on the Burton Process of 1913, reported to be the first commercial cracking operation:

"Such stills were designed to have a safety factor from 400 to 500 per cent based on known strength of mild steel at ordinary temperatures. Actually, in the light of later knowledge about rapid loss of strength of steel above 550 F, these stills had a safety factor of only about 50 per cent (*Note:* Strength of steel increases to some extent up to 500 F, above 500 to 1000 F its strength is one-half that at normal temperatures, and, at 1200 F, it is less than one-quarter.). It is remarkable that hundreds of stills were operated for 8 years before any fatal accident occurred, although there were numerous fires."

"It was practically impossible to keep the riveted seams from leaking, no matter what care was exercised in fabrication. In some plants, a man with a steam hose was kept busy putting out fires caused by oil leaking from seams and around rivet heads. In one case, the refinery caulkers refused to work on the leaky seams of a still in operation at the Whiting (Indiana) refinery and the renowned Dr. William M. Burton caulked the seams himself."

Other troubles of that day included coke accumulations which gave rise to localized overheating and "hot spots" on still bottoms — the appearance of a bulge was a common signal for shutting down fires and hurriedly emptying the stills. Operating periods, at one time, seldom exceeded 24 hr between "clean-out" shutdowns. Water-steam explosions were almost ordinary occurrences, wherever water was used for emergency cooling. The appearance of the Dubbs cracking process in 1919 permitted stills to be operated continuously for 8 days, at pressures of 135 psi and temperatures around 850 F, in contrast to 75 psi and 600 F employed in the Burton process.

Hammer-welded and riveted vessels passed out of the picture about 1930 with the rapid development of the electrical welding process. The use of X-rays greatly improved the efficiency of the welding techniques. It must be remembered that when cracking plants began to operate, there were no codes that applied to their construction and operation. The then existing U. S. boiler code was inapplicable in many respects. Insurance specifications and state regulations were soon supplemented by new codes gradually developed by joint efforts of the American Society of Mechanical Engineers and the American Petroleum Institute. The first edition of this special code, covering minimum construction standards and inspection requirements for cracking equipment, was used in 1934, and the fourth and latest edition was issued in 1943. The present ASME-API Code covers design, fabrication, and stress-relieving requirements, and such protective features as pressure relief and emergency blow-down devices—it is currently undergoing revision. The safety of these pressure vessels and appurtenances has been further aided with the development of such non-destructive inspectional test methods as strain gages, radiography (using radioisotopes), ultrasonics, and magnetic particle (magnaflux) and fluorescent powder (zyglo) techniques for detection of surface imperfections and deep-seated flaws. Parallel metallurgical developments led to the use of stainless steel alloys in tubular reactors and furnaces which today are found operating at pressures ranging from 3000 to 5000 psi and at temperatures close to 1000 F. The never-ending task of constant code revision is a safety matter of foremost importance in modern petroleum operations.

Another serious source of "early-day" troubles arose from the common practice (prior to 1920) of using wooden-roof steel tanks for the storage of crude oil and finished products. Because of the relatively free venting to the atmosphere, ignition by lightning and sparks induced by distant electrical storms became the most common cause of tank fires. A survey by the American Petroleum Institute revealed that of some 230 tanks ignited by lightning, 93 per cent were not gas-tight. It may also be of interest to report that during this period a U. S. Bureau of Mines investigation on evaporation losses showed that nearly $200,000,000 worth of gasoline evaporated from the crude oil and refined gasoline produced and handled in a single year.

In time, the industry became acutely conscious of these losses and undertook an intensive program of introducing gas-tight steel roofs, conservation vents, and pipe line gathering arrangements with central recovery systems, along with lightning protection and improved grounding of tanks. Other developments for safe-guarding the storage of liquids included floating roofs, blanketing with inert gases, pressure, and vacuum relief vents with "flame arrestor" protection, and vapordome roof tanks. With the recovery and utilization of high vapor pressure casinghead gasoline, and such by-product gases as propane, butane, and butadiene, pressure-storage spheres, and variously designed spheroids came to be employed for compressed storage of these newer products.

Early efforts of combatting and extinguishing fires fell far short of their good intentions—as evidenced by the record fire losses which at times reached $20,000,000 annually. In the days of the wooden roofs, it was the practice to introduce steam into the tanks upon approach of a storm, but this measure was not too successful. Investigations disclosed that steam failed because there was not enough of it; the capacity of the steam plants in the field was generally insufficient to produce the required quantities of steam. To avoid costly fires, other precautions such as spacing of tanks and use of dike walls, to guard against "boilover" and dangerous spread of fire, were resorted to. Subsequent experiments with combinations of chemical solutions led to the development of

stabilized foam-blanketing techniques for excluding air and suppression of flame. The use of this system spread rapidly throughout the oil industry with portable and built-in adaptations by the end of World War I, where it continues to be the recognized method for large-scale use on oil tank fires or other flammable liquid fires where a smothering and blanketing effect is required. Other new methods are constantly being developed, but, because of its record over a period of many years, foam has become to be regarded as outstanding for its suitability and reliability in the petroleum and related industries.

This resume of the vast developments and progress of fire safety in American oil refining and petrochemical processing should be of particular interest, in view of the current oil boom in Western Canada. The expanding activities in the Prairie Provinces are expected to make timely and important contributions to the world supply of petroleum, and to Canada's industrial activity in general. This is most encouraging to our neighbors south of the border, since North America consumes 65 per cent of the total supply. Interestingly enough the comparative consumption rates for U. S. and Canada are 595 and 361 gal per person, respectively; 76 for Latin America, 35 for Australia, and 48 and 55 gal per person for Europe and the USSR. The unrest in the Middle East could cut off important deliveries overnight. Canada supplies just one-third of her needs at this time, while the U. S. continues to be a heavy consumer—the refineries are currently operating at near capacity with an all-time high of 7,000,000 bbl daily. A stage has been reached where the imports exceed the exports—until 1948 the United States had been a petroleum exporter. Because of the impetus of times, the demands for petroleum products continue to soar over and above wartime demands.

The now active operations in Alberta, Saskatchewan, and British Columbia promise to usher an epoch of modern industrialization. More than 150 Canadian and 50 major U. S. oil companies are currently making extensive explorations and are already conducting important operations in the Williston Basin. This saucer-shaped sedimentary formation is reported to be similar to that in Texas and covers about 100,000 sq miles, extending from the western two-thirds of North Dakota, northwestern South Dakota, through the eastern part of Montana, southeast Saskatchewan, and southwest Manitoba. In years to come, this huge basin is expected to play an important part in the oil supply picture. Saskatchewan Province now ranks after Texas, Alberta, Oklahoma, and Louisiana in terms of oil and natural gas explorations and development, although, prior to 1949, practically no oil or gas activities existed there. Though considerably less than the 30-billion barrel reserve of the United States, the proved reserves thus far have reached 1½ billion barrels, but it is anticipated that the combined potential might exceed 5 to 10 billion barrels. With new favorable potentials in British Columbia and in the Northwest, this reserve total has been predicted by some to reach a possible 50-60 billion barrels. However, what is possibly the world's greatest reserve of oil lies in the Athabaska tar sands in Alberta (175 miles northeast of Edmonton, oil capital of Canada), with an estimated reserve of 200 to 300 billion barrels (with a relatively costly recovery problem). The Alberta gas fields hold much promise as a major supply of fuel with their reserve of 26 trillion cu ft (The U. S. reserve is about 180 trillion cu ft, and the annual consumption has reached 7.5 trillion), and, with the completion of our current inter-governmental negotiations for a mutually acceptable east and west conservation - and - supply program, a good market is expected in our Pacific Northwest.

More than $1 billion have been expended in Canada for oil operations since the 1947-48 period, which marked the beginning of the great Leduc-Woodbend and Redwater fields. The great distances and severe elements may increase your "growing pains", but they will be overcome in time. Already an important crude supply pipe line of some 1200 miles is underway from Edmonton to Superior, Wisconsin, on the Great Lakes, to permit moving oil to refineries in Ontario (Sarnia) and Quebec (Montreal). With the announced location in Canada of one of the largest synthetic chemical operators and a producer of intermediate consumer goods, your future in the petrochemical field is off to a good start.

As it may be surmised, the foregoing discussion was submitted to provide material emphasis to the paramount importance of providing proper fire prevention and fire protection to our valuable petroleum resources and their associated chemical industries. This discussion would not be complete without at least a summarized presentation of some of the essential items of fire safety that must be considered to effect a well-protected operation. The following generalized comments and broad recommendations should expedite intelligent thought and practical planning in this direction.

1. Features of importance in oil field operations include: The hazard of "blowout" and serious cratering (well pressures of 6000 psi and craters up to 400 ft across are known to have occurred — covering several acres of ground with mud up to 10 ft deep), gassy fields without proper control of gas hazards; the hazard of grass and weeds, underbrush, tumbleweeds, or other flammable refuse. Wood derricks have been a major hazard because of their ease of ignition by lightning or other causes (steel shortages and accessibility of lumber may result in their preferential use in remote areas). Abandoned dry-holes in wildcat operations may contribute to troubles of fire control. Fields subject to floods, overflow of oil, heavy snow, and severe cold weather will require advance planning in fire fighting. Accidental setting-off of blasting caps by electrical induction, through shortwave radio or radar operation, must not be overlooked.

2. Fires in tank storage and terminal-loading service areas may be caused by such hazards as lightning and atmospheric electrification (sandstorms and dry snowstorms), overflow spillage and corrosion leaks, careless riveting and welding repairs, including exposures to grass and other incendiary fires. Storage is relatively the simplest of all problems, yet it brings up a number of important items that deserve careful attention. Some of these that should be considered are as follows: Location of tanks to avoid uncontrolled burning liquid from flowing downhill into a congested or high value area, suitable spacing and diking provisions for containers of flammable liquids, flame control on vent openings, and protection from static hazards resulting from turbulence of hydrocarbons during handling, by proper grounding.

3. Refining operation areas hold great energy potentials in processed materials and therefore call for certain safeguards that begin with basic design and functional layout. For instance, piping cross-connections between the various services must be guarded against at all times. Processing equipment should be arranged with adequate distances to provide access to all necessary controls in the event of an emergency. Pressure relieving and blowdown facilities should be provided with means of disposal of released materials to safely remote locations. Unusually hazardous areas and their "hot operations" (cracking and high-pressure installations) should be segregated from all critically important equipment to minimize their involvement in the event of fire.

Other features to be considered in fire protection planning and design include special combustion-suppressing drainage systems to divert the liquids from uncontrollable leaks (pump failure, piping and vessel rupture) to distant burning areas. Fire-retardant construction (concrete encasement, thermal insulation, and surface coatings) and fire-wall barriers, along with fog protection and water curtains have been advantageously incorporated in good design to minimize the effects of primary fires beyond the loss of material involved. Fire alarm systems and organized industrial fire brigades, and their coordination with municipal fire departments, are important items in planning fire protection programs.

A brief breakdown of some of the principal contributing factors in processing fires and important preventive measures which should be considered in the establishment of a fire-safe program includes the following:

a. Misoperation and faulty practices by operators or others having delegated responsibility are recognized to be leading sources of trouble. Improper performance of duty, whether it be charged to neglect or "error of judgment", generally results from the lack of complete information on hazard potentials of materials handled and performance

limitation of equipment being operated.

Many organizations maintain extensive job-training programs in which workers are comprehensively schooled and properly indoctrinated with steadfast rules for even the most routine daily tasks. Well-planned instruction includes an assessment of hazards associated with each operation, standardized procedures for starting-up and shutting-down equipment, purging and blowdown procedures, and other emergency countermeasures vital to the safety of equipment and personnel. Poorly trained maintenance and repair personnel leads to considerable difficulty and is chargeable to misoperation. Many accidents are traceable to improper practices during repair and the lack of adequate safeguards.

Serious fires and life loss are known to have occurred with attempts to repair equipment without shutting down and removing flammable contents and other hazardous materials from the system being repaired. Safe-working permits should be considered an indispensable requirement for all construction and repair work in designated "hot areas". The permit system should cover welding or hot work away from shops, including the opening and entering of hazardous equipment. This procedure engenders a definite safety consciousness on the part of all concerned.

b. Equipment failure presents another common operational source of fire and explosion accidents. The increased severity of hazards found in the accelerated operating conditions of present-day petroleum operations calls for extensive inspection and checking systems, along with scheduled replacement of pressure vessels and other equally critical equipment. Improper servicing and inspection deficiencies can lead to unwarranted situations that generally exact heavy tolls in life and property.

Planned inspections and inventoried maintenance are founded on good engineering and successful operation. Preventive maintenance includes the establishment of wear and corrosion rates and scheduled calibration of all critical instrumentation, including performance tests on all safety controls (relief and blowdown valves, rupture diaphragms, etc.). These activities are considered a part of production and call for competent engineering supervision and direct reporting to management.

The trend toward this type of engineered inspection and servicing is indicated in the record of one of our larger organic chemical establishments. Their fire protection and safety department conducts some 45,000 routine inspections and tests annually, involving nearly 90,000 man-hours of engineering service. Their annual program includes scheduling some 10,000 piping tests, 4000 equipment tests, along with the testing and servicing of some 11,000 safety valves, 14,000 pressure gages, and 4000 routine examinations and checks of flame arrestors, flammable vapor indicators, and various process control equipment. It is interesting to report that over the past five-year period this organization experienced a 25 per cent decrease in fires and a 90 per cent decrease in losses—this was accomplished in the face of a 30 per cent expansion!

Accidental fires occur in spite of preventive measures, and, consequently, foresighted preparedness with proper fire protection must be made a part of a complete fire safety program. As has been indicated, the swift pace of our technological progress can bring about new extrahazardous processes that may render the ordinary fire extinguishing equipments and procedures unsatisfactory, if not obsolete in some instances. The special protective devices to be developed provide a continuous challenge to the ingenuity of the fire protection engineers and the skilled "know how" of firemen. It is apropos at this point to just mention something about the present progress and new fire control techniques that are in the forefront and hold promise for the future. There are four items that ought to be covered in connection with petroleum fire fighting as they indicate important development trends:

1. Water is still to be regarded as the outstanding medium in fire fighting operations—recent developments in mechanical applications are enhancing its usefulness for control and extinction of flame. A recent survey indicates that 50 per cent of the refining capacity in the United States is protected by fire systems capable of delivering 5000 gpm of water or more, which stresses the importance the refining industry places on water for fire protection. Actually even larger water supplies are desirable, when feasible, to minimize damage. Fixed automatic water spray (fog) systems, requiring instantaneous water supplies of substantial pressures upward of 60 psi, at delivery rates as high as 20,000 gpm, are being employed in the larger installations. Water sprays can extinguish fires in flammable liquids having flash points of 120 F or higher, by cooling, when complete spray coverage of the surface is obtained (care must be exercised against danger of reflash), spills of soluble flammable liquids can be extinguished by dilution. Water can also be used to control the burning rate of low flash liquids or to cool the flames of gases, and protect personnel in the fire zone to permit access to valves controlling flammable products. Direct impingement of water sprays on pressure vessels, piping, valves, fittings and supports can provide good exposure protection of such equipment and their supporting metal structures. The addition of "wetting agents" to water has been found to increase the wetting and cooling of water repellent surfaces. Other chemical additives are being developed to promote emulsification and frothing (akin to foam production) of immiscible liquids. Applications of water through deluge curtains and spray systems are being designed for all kinds of protection: Extinguishment, controlled burning, exposure safeguarding, or for prevention of occurrence of fire.

2. Another fairly recent development makes use of an automatic mechanical

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air-foam system. This procedure combines the advantage of automatic sprinklers, water sprays, and foam, coupled with standard rate-of-rise heat detection, to provide cooling and smothering on a large scale through the formation of a "foam storm". An arrangement permits injection of a foam liquid into the sprinkler system, which is aerated as it discharges through the spray heads. A uniform downpour of finely subdivided foam, looking like a snowstorm, is produced. Because of adhesion of such foam coatings to ceilings and vertical structures, torch-type fires can be guarded against in various critical areas. This system is reported to be applicable in buildings housing processing and pumping equipment, and around tank car unloading and flammable liquid storage facilities.

3. Another rather unique fire control method for oil tank fires, developed by a major oil operator, is worthy of mention. It includes a new technique through turbulence created by injection of air of low pressure into the lower portion of the tank to send cooler subsurface oil to the top; the cold oil spreads over the surface and cuts down the vapors on which flames feed. In a 100,000-gal tank of kerosine a fire was extinguished in five seconds; blazing crude oil was reduced in intensity and brought under control in 45 sec, permitting the retarded flames to be completely extinguished with foam. The only facility required is a supply of compressed air 6 psi to provide the necessary agitation. This technique also helped to prevent dangerous "boilover" spills in oil fires, by preventing heat waves from traveling downward to the water layer, which would form steam, with a pushing-out frothing action. The results with this simple procedure are almost unbelievable.

4. One unusual application of dry powder should also be mentioned in connection with petroleum and natural gas fires. This concerns a spectacular oil well fire (Venezuela) that raged for five days —where preliminary attempts at extinguishment by foam, steam, water and CO_2 all failed. In this instance the drilling rig and tower were blown out with the formation of a large crater. By throwing up a semicircular, earthen barrier or diking with a bulldozer, and wheeling in 6—150-lb dry powder units and spreading out 20—30-lb hand portable units around the periphery, the fire was extinguished in 50 sec. This was immediately followed with water streams to prevent a "backflash". After the fire was out, the well was recapped in four days. This was the largest fire yet extinguished by means of dry chemicals.

The prime objective of this presentation has been to bring together, in summarized form, the salient fundamentals of fire safety in petroleum processing and to instill a fuller appreciation of extreme importance of duties connected with this broad field. Believing that safety in general will be aided by greater dissemination of information, those concerned with the furtherance of fire prevention and protection in this prime field are recommended to familiarize themselves with the following three groups of authoritative publications:

1. The recently published comprehensive text on refinery fire and explosion problems: *Safety In Petroleum Refining and Related Industries,* compiled by George Armistead, Jr., Washington, D. C. (425 pages—1949—Goetz Lithographic Company, Inc., Washington, D. C.)

2. The special series of inspection manuals prepared by the American Petroleum Institute, 50 West 50th Street, New York 20, N. Y.

Recommended Practices for Refinery Inspections

Part 1, Process Equipment (1948).

Part 2, Pressure Relieving Devices (1949).

Part 3, Fire Protection Equipment (1950).

Part 4, Low Pressure Storage Tank (1951).

3. The well-known and widely accepted standards and specifications of the National Board of Fire Underwriters and the National Fire Protection Association pertaining to construction, storage and handling of flammable liquids and hazardous gases, and recommended fire control measures. Special technical reports of the National Board and the Fire Loss Bulletins of the National Fire Protection Association, recently instituted as a part of their flammable liquids field service, should be reviewed regularly.

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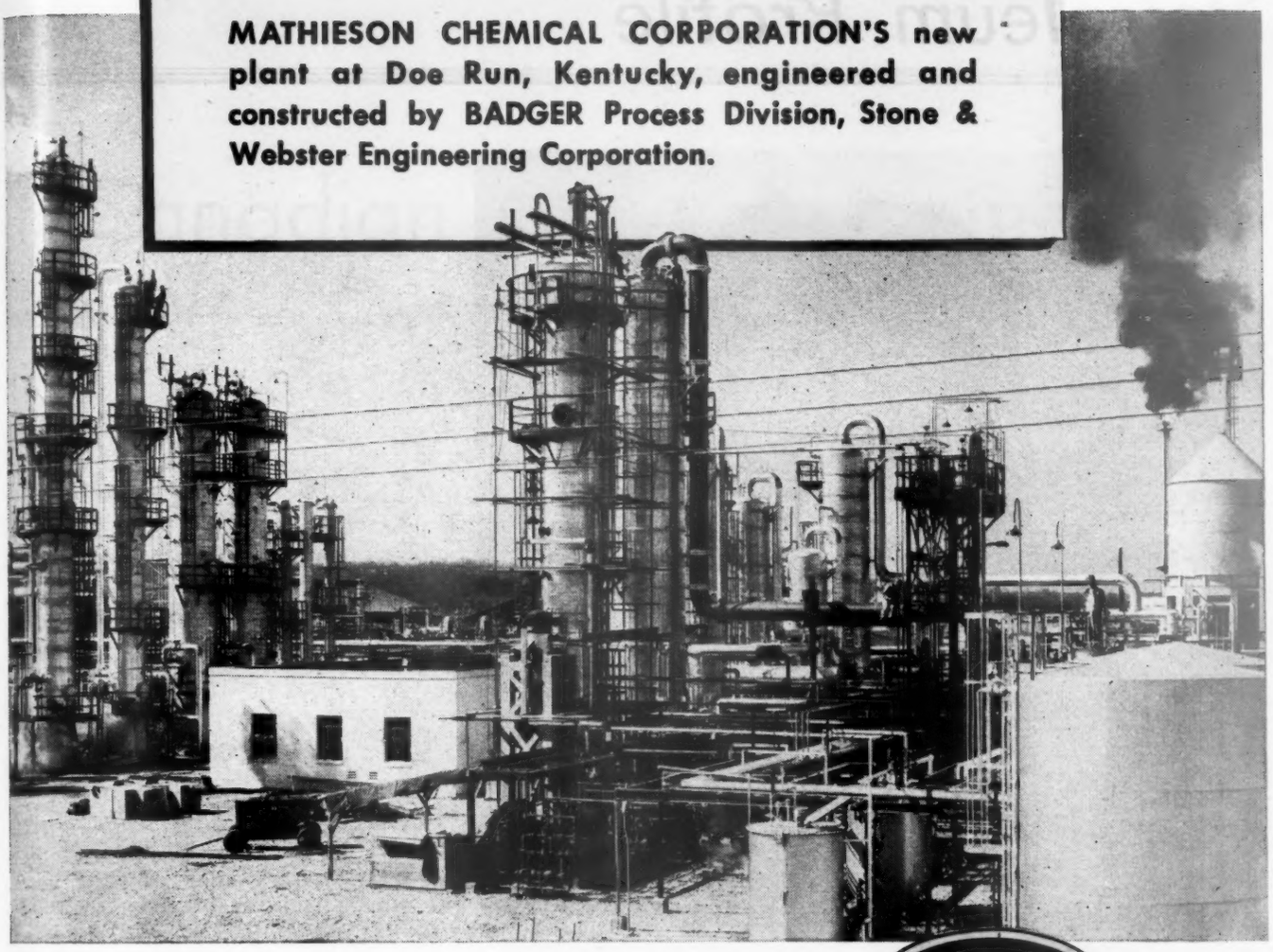

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Petroleum Profile

DR. KENNETH M. WATSON
Director of Research
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DR. KENNETH M. WATSON, well known scientist and oil technologist, has been appointed director of research for Pure Oil Company, with headquarters at the company's research and development laboratories in suburban Crystal Lake, Illinois. Dr. Watson succeeds the late William B. Ross.

Dr. Watson has been prominent for several years in applied research and development work, in consulting and in educational activities, and writing works on engineering and chemical subjects, including four chemical engineering texts, and a three-volume study of "Chemical Process Principles", all of which are employed widely as educational texts. Research professor of chemical engineering at the University of Wisconsin — where he was awarded the doctor's degree in 1929 — from 1942 to 1950, he has been active in governmental work and in a consultant's capacity to the chemical and petroleum industries since the early 1920's.

His first prominent connection with petroleum chemical engineering research began with his affiliation with Universal Oil Products Company of Chicago and Riverside, in 1931, where he directed pilot-plant and physico-chemical investigations and later was made director of engineering research, leaving that position in 1941 to join Gulf Oil Corporation's engineering staff. He headed the technical committee for Neches Butane Products Company, one of the largest butadiene manufacturers during World War II and since, and so collaborated with Petroleum Administration for War, Rubber Reserve, and other wartime Federal agencies vitally interested in and charged with production of synthetic rubber and its intermediates butadiene and styrene. In this position he had outstanding influence on the developments, which provided the U. S. and her Allies with rubber when rubber was indispensable to winning the war. In 1948 the American Institute of Chemical Engineers granted Watson the William H. Walker Award for his outstanding contributions to chemical engineering literature.

Other agencies of the Government with which Dr. Watson has collaborated include consultant status with the War Production Board; technical adviser to the President's Interagency Committee on Carbon Black, when that product vital to rubber manufacture was in a critical position in 1945. He has consulted with a large number of private companies on chemical engineering problems, and has had a directing hand in the development of a great number of processes employed by the chemical and petroleum industries.

Dr. Watson is a member of various technical societies, including the American Institute of Chemical Engineers, American Chemical Society; Wisconsin Academy of Arts and Sciences, American Association for the Advancement of Science, and the American Society for Engineering Education. He has contributed many various papers on engineering subjects before all of these bodies.

Dr. Watson lives with his wife and daughter at Zurich, Illinois.

Canadian Oil Achievements

The producing area of the Canadian oil industry is in the west and is largely in the Province of Alberta. The Western Canadian sedimentary basin covers an area of 800,000 square miles and the present day average producing depth is about 5000 ft. The cumulative production in Alberta to mid-1952 is about 200,000,000 bbl of oil, and the annual figure for 1952 is 46,000,000 bbl, an increase of almost 100 per cent of the 1951 production.

The rapid expansion of Canada's oil industry dates back to Imperial's Leduc discovery well in 1947. Prior to this discovery the production in 1946 was approximately 7,000,000 bbl of oil. In a period of 5 years outstanding progress has been made, but as a corollary it must be stated that such is only the beginning, the essential growth will be without doubt phenomenal. The oil and gas potentialities of Western Canada are infinite and only the vaguest conception of its recoverable reserves is realized at present.

Winter conditions are severe and sub-zero weather creates many operational problems, and activities are restricted. Total footage drilled per month during the late winter was about 350,000 ft and during the summer of 1952 the rate was anticipated to be increased to 560,000 ft per month — an increase of 60 per cent, which emphasizes the extreme conditions.

Canada still needs to import oil and it is potentially 50 per cent self sufficient, but due to inadequate facilities the figure is actually reduced to 33 per cent. If the reciprocal oil agreement between Canada and the USA materializes then Canada should be 100 per cent self sufficient "on balance" in 1957.

The production during the winter months is seriously curtailed on account of the freezing of the Great Lakes, and a cut back of 100,000 bbl of oil per day is necessitated. The completion of the Trans Mountain pipe line will alter the picture in the near future when 75,000 bbl of oil per day can be delivered to the British Columbia area.

The estimated Canadian proved recoverable reserves in place in 1946 were 100,000,000 bbl of oil, today they are 1.4 billion, an average increase of almost 300 per cent per year. Estimated proved recoverable oil reserves in place of a few of the major fields are: Redwater 630,000,000 bbl, Leduc-Woodbend 200,000,000 bbl, Golden Spike 106,000,000, Wizard Lake 50,000,000, and Turner Valley 18,000,000. (The Turner Valley field has produced more than 100,000,000 bbl of oil since its discovery in 1914.) The proved gas reserves in Alberta have been estimated at 6.8 trillion to 8.6 trillion cubic feet.

The discovery of oil in the Williston Basin, in North Dakota and Montana in the United States, has raised hopes that production from the portion of the basin, that extends into the Canadian provinces of Saskatchewan and Manitoba will be substantial. At mid-1952 Socony had completed a discovery oil well in the basin in southern Saskatchewan. The previously estimated reserves of this Province were 20,000,000 bbl of oil.

Canada is conducting an extensive exploratory program and development continues at a high pace. The 1952 expenditure on land purchases, exploration, and development is anticipated to exceed $230,000,000. The vast reservoirs of the Canadian Prairie are being made to flow their crude. The past 5 years have yielded much, the next 5 will surely surpass those amazing achievements.—J.M.

it's new

it's successful

packers by Baker

The Baker-Otis Selective DUAL-ZONE Production Hook-Up, which includes two Baker Retainer Production Packers, permits selective production (either pumping or flowing); acidizing, formation fracturing, and other treating; or testing of *either* zone through the tubing while simultaneously producing the *other* zone through the annulus. The switch in flow, or the selection of either zone for treatment is accomplished at the discretion of the operator, using a wire line, and it is not necessary to kill the well—to move or remove the tubing string—or to disturb the Baker Packer hook-up in any way.

COMPLETION ADVANTAGES

SAVES INSTALLATION TIME—You can perforate, set the Baker Packers, and complete the well by *simply running in the tubing*. Previously it has been necessary to make *at least two additional trips* with the tubing, killing the well each time.

SAVES EXPENSIVE DRILLING RIG TIME—After the Baker Packers have been set, the tubing run in, and surface connections made, the drilling rig can be moved off. All future work can be done with a swabbing unit and a pump truck—at distinct savings.

PROVIDES SAFETY IN HIGH-PRESSURE OR HYDROGEN SULPHIDE WELLS—Surface "flanging-up" is completed before the mud is displaced. After the mud has been displaced work is performed by using a wire line and wire line tools through a lubricator. This is a highly important advantage in high-pressure or hydrogen sulphide wells.

EITHER ZONE CAN BE TESTED WITHOUT REMOVING TUBING—Not only while the well is being completed, but at any time therafter, *either or both* of the zones can be tested *without removing the tubing string* or disturbing the packer hook-up installation.

ELIMINATES EXTRA ROUND TRIPS FOR ACIDIZING OR FORMATION FRACTURING—In the past, treatment of either or both zones has been carried out *before* the packers were set. This practice not only prolonged the completion by necessitating extra round trips, but subjected the zones to the full mud load during the interval between the completion of the treatment and the termination of the packer installation. The Baker-Otis Selective DUAL-ZONE Production Hook-Up, on the other hand, permits treatment of either or both zones at any pressure that is safe for the tubing, *at any time during the life of the well.*

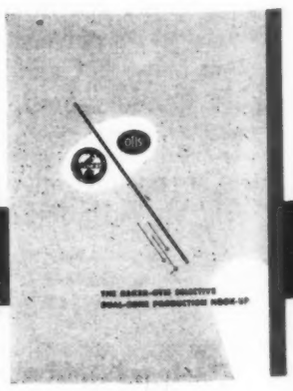
PRODUCTION ADVANTAGES

PERMITS SWITCHING FLOW—Should the character of either zone change at *any future time*, the flow can be switched—even under pressure—by running in the appropriate Otis Choke on a measuring line.

PERMITS PLUGGING FLOODED ZONES—If either zone should load up or flood out, it can be plugged at the cross-over.

PERMITS SURFACE WORK WITHOUT KILLING THE WELL—If at any time it is necessary to overhaul the surface equipment, the annulus can be shut off at the cross-over. All needed work can then be done *without* killing the well.

GET YOUR COPY
of this new, three-color broadside which contains complete details of the Baker-Otis Hook-Up, with ordering instructions. Ask any Baker representative, or write the nearest Baker office.



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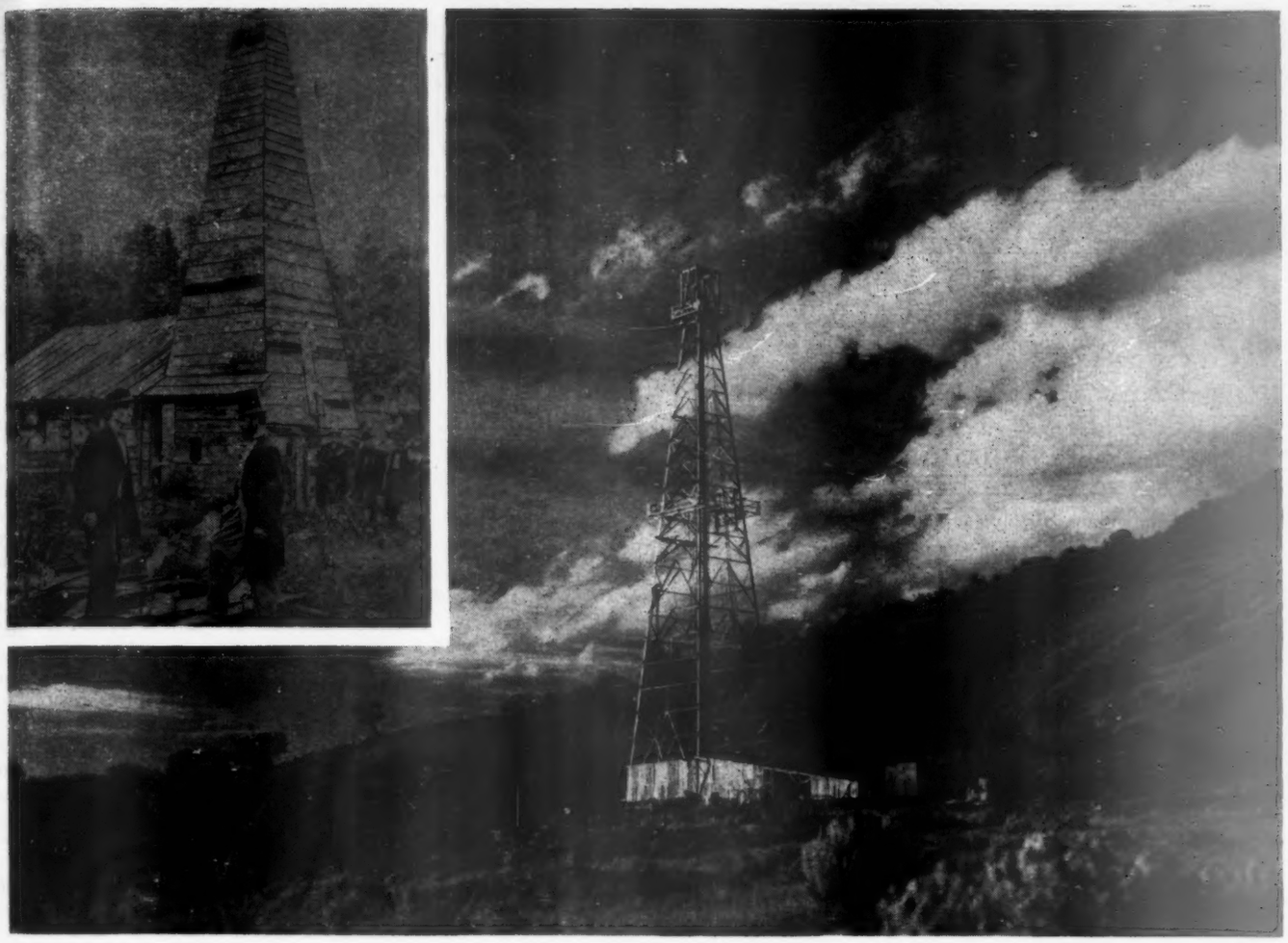


Drake's drilling outfit (inset) was as far from the modern rig as the *Clermont* from the *U.S.S. United States.*

What Spurs Oil Progress?

Industry leaders point to a score of items that have accelerated the swift advancement of recent years

ERNESTINE ADAMS*

COLONEL DRAKE'S drilling tools cost $76. They were made by William A. Smith at Tarentum, Pennsylvania, and weighed 100 lb. Power came from a 6-hp engine and a stationary tubular boiler.

The use of petroleum, as we know it—part of the life of every citizen of the United States—would have faltered and gradually come to a final close without the progress of tools and methods that has been a miracle of free industrial activity.

There are some who say that drilling operations have not fundamentally changed since Drake's well. That may be true but machinery and procedures then and now are as far apart as Fulton's *Clermont* and the *U. S. S. United States,* as different as the Wright brother's aeroplane and the modern jet.

In between is what is known as progress. And the success of the oil industry's progress is that with tools becoming more complicated and more expensive, the products of its effort have steadily declined in price until it truly produces oil for all the people.

When Drake found oil it was for use as the new cheap and reliable illuminant, a crudely distilled "carbon oil" that Samuel Kier was selling for $2 a gallon. Now there are 11,000 uses of this crude petroleum and it runs from the earth in wonderfully efficient rivers of power for the comfort and protection of our nation.

EXCLUSIVE

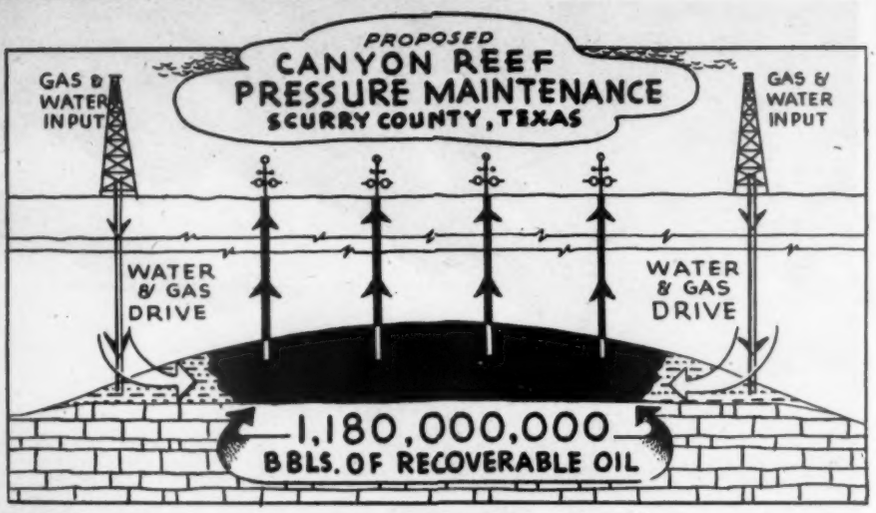
What Lately?

In the words of the citizen whose vote was solicited by a generous politician, we asked the oil companies: "What has progress done for us lately?"

What are the methods and equipment now in the field that contribute most to the oil industry's progress? The question was put to 100 oil companies in the drilling and producing branch of the industry. About half gave opinions; others who answered could not choose among many contributions.

The list of improved methods and

*Managing Editor.



Pressure maintenance a great engineering advance.

equipment, which got the vote of the top men in drilling and producing, is varied and, lumped together, takes on fantastic proportions in view of their accomplishments. It would be hard to imagine what our industry operations would be like without these modern tools of progress.

You will note that most of these combine an advancement in equipment and the application of improved methods, which incorporates the progress that has been made in "know-how." The list is far from complete. In fact, there is no part of the industry that cannot record progress. There is only one thing we can be sure of—next year both methods and machines will be better.

Briefly the operations and tools that won the award of approval are described below.

1. Pressure Maintenance

One of the greatest engineering accomplishments of the modern oil industry is the successful application of pressure maintenance in petroleum reservoirs so that an increased and more efficient recovery is possible.

In recent years the growth of unitization projects, which installed water flooding and gas and air pressure programs, has spearheaded the search for ever higher recovery.

In this issue W. S. Morris discusses pressure maintenance as applied to the famous East Texas water flooding and salt water disposal project on Page B-63.

2. Artificial Lift

"Artificial lift equipment is helpful in increasing current and ultimate production of oil," reported Southern Production Company, Inc., which considered artificial lift significant in producing improvement.

Tools for artificial lift, pumps and gas lift equipment, have shown a steady trend toward more efficient operation and have delivered results in the form of increasing current production and of ultimate recovery of oil.

3. Instruments

In the drilling of a well if an oil operator were able to know precisely the exact formation and the producing potential of the penetrated interval, conditions would be close to ideal. It would be highly advantageous if it were possible to determine the capabilities of a well from an electric or radio-active log. Progress is directed toward these objectives.

"Electric and gamma and neutron logs are yielding more information than ever before on the character and content of formations—whether they contain oil, gas, or water," the Sun Oil Company stated. Among others, Honolulu Oil Corporation's opinion was that possibilities of electric logging were keeping pace and that the special type electric logs, such as induction, monoelectric, multiple resistivity curves, and jumbo scale curves, were highly important in oil progress.

The introduction of jet perforating has brought about the possibility of a greater depth of lateral penetration into the producing zone. This is another tool used for the purpose of obtaining an increase in recovery.

4. Retrievable Packers

A new method of completing a well with greater safety and at less cost has lately been devised, calling for the use of special packers. The account of the first well completed by this means was reported in The Petroleum Engineer, July, 1952, Page B-80. The operators of the North Dakota well using the method, Rudman, American Viking Corporation, and Tioga Petroleum Corporation, estimated they saved $25,000 by the retrievable packers method.

5. High Gel Cements

Houston Oil Company of Texas gave as one of the greatest steps forward in the drilling branch of the petroleum industry, the development and use of high gel cements for primary cementing of casing.

The term "high gel cement" is defined as a common Portland cement with from 10 to 15 per cent bentonite added. This mixture allows approximately a 15 per cent saving in the cost of the primary cement jobs. It also provides a low strength cement that facilitates perforation and reduces the shattering effect of perforating. The use of high gel cements has been generally accepted during the past year in the Gulf Coast area, and this mixture is becoming more widely used every day.

6. Formation Fracing

The application of fracing—"lifting the formation so that the oil can flow more freely"—has wide possibilities. By employing this method many wells which would have otherwise been failures, or uneconomical, have produced oil.

" 'Sand-frac' service has a tremendous future and is a major contribution to the science of producing oil from low permeability sands," stated Bankline Oil Company.

"A completion method that is one of the most outstanding improvements of recent times, is the use of Hydrafrac and the other 'fracs' that have recently come into the market,' was included in a statement from Skelly Oil Company. "A great deal has been written about this method of well completion, and while much more can no doubt yet be learned through the use of these various 'frac' completions, still the results so far obtained have been remarkable. This method has become a fully accepted practice in completing wells where sand conditions are favorable, pretty much as we used to think in terms of shooting with nitroglycerin. There is quite a saving in the use of Hydrafrac over shooting with nitro glycerin; that is, in the cost of cleaning out wells after shooting," the report added.

7. Dual Completions

Often a well penetrates two distinct producing pays and causes much debate about whether a dual completion or a twin well completion is the more advantageous. Strong reasons usually influence a particular choice for using one or the other. The questions of economics and reservoir behavior arise.

The steel shortage limits temporarily those who favor the twin well. Much progress, also, has been made during recent years in dual completion equipment.

8. Drilling Fluids

One of the more spectacular advancements in drilling is the improvement of drilling fluids, including the new oil emulsion fluids. Recent innovations mean drilling fluids chemically fitted to specific conditions. High pressures, heaving shale, formation waters are held back by the versatile drilling fluids that must be light weight enough to permit testing and heavy enough to ward off blowouts and prevent formations from heaving.

Without the attention given to drilling fluids, deep drilling in most instances would be impossible.

9. Rigs

Speed of drilling operations has been increased by several improvements. Greater power and greater range are evidenced in the new diesel-electric rig developed by Standard of California on

Page B-42 and in the power-driven machinery described on Page B-42.

If speed had not been increased in recent years, perhaps double the 5500 rigs in the country would be needed; it would be impossible to drill almost 175,000,000 ft (1951) in one year, and deep wells in general would be too costly to consider.

Design of drilling rigs have in the last few years emphasized portability, automatic and semi-automatic devices, and greater power.

10. Barges

"Bigger and better drill barges" drew a comment from Sun Oil Company as a sign of progress. Today even in open water such as the Gulf of Mexico drilling operations are carried on with reasonable safety, and depths can be reached from drilling barges undreamed of only a few years ago.

In more shallow water, barges have been designed for use under a wide range of conditions. The submergible tank battery barge developed by Gulf Oil and the YF tender barge for drilling operations described on Page B-86 are other versions of over-water equipment that advances drilling and producing operations.

11. Diamond Drills

"Diamond drill coring has played its part in the important job of obtaining information from wells."

Good core recovery is not the only operation expedited with the use of diamond drills. In penetrating very hard formations diamond drills are used when conventional bits are sometimes ineffective.

12. Permanent Type Completion

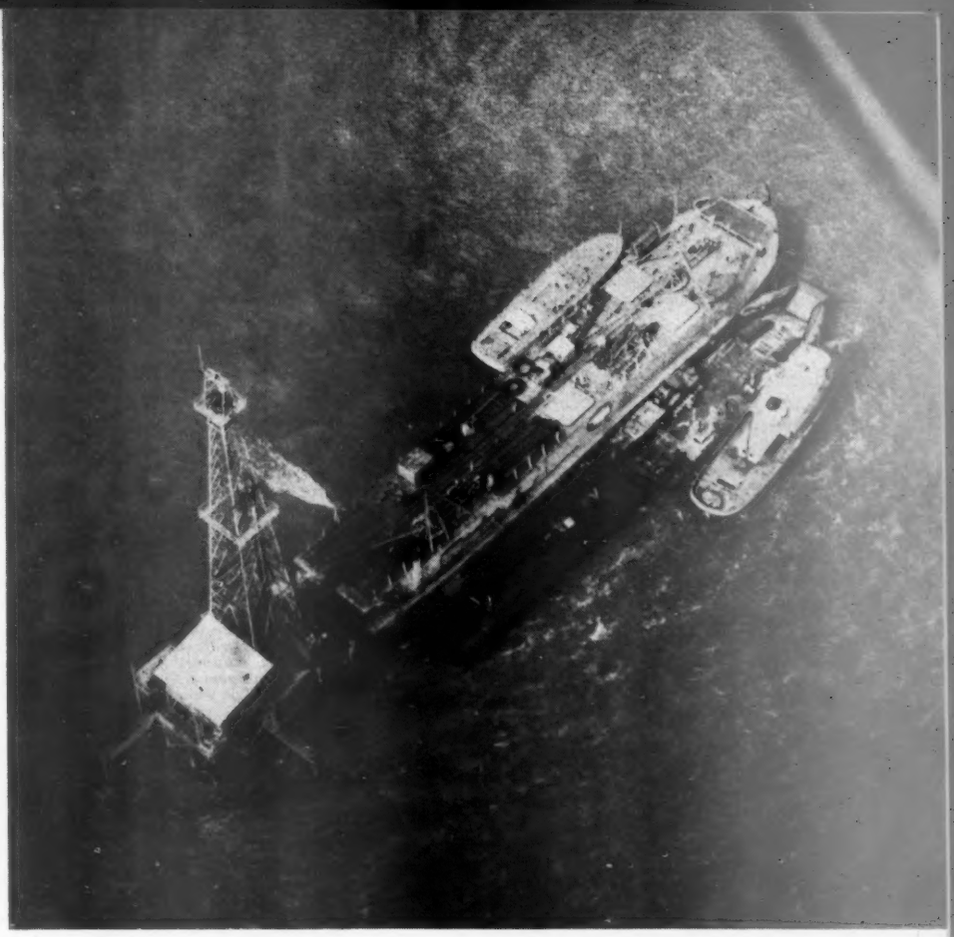
Considerable thought has been given over the years to the idea of reducing work-over costs. Remedial measures can become expensive and in marginal wells prohibitive. If certain operations could be conducted through the tubing much time would be saved. A tubing type perforating gun and plugging back through the tubing without employing a rig would be advantageous. Experiments have been carried out successfully along these lines and Humble Oil and Refining names it as a progress item for production. A brief description of the permament type completion is on Page B-18.

13. Jet Bits

Imperial Oil, Ltd., considered application of jet bits to drilling outstanding in the advancement of drilling equipment. The jet bit is a tool that has under certain conditions increased rates thereby reducing operational costs of penetration. The bit has been widely acclaimed as a great contribution to modern drilling practice.

14. Plastic Tubular Goods

Tubular goods made of plastic and other non-metallic materials promise to be a means of reducing loss through corrosion. Additional improvement in the physical characteristics of such pipe in conjunction with its inherent resistance to corrosion should result in a material having wide application in lease and well equipment and may increase oil recovery because of the longer economic life of leases, according to one company. The steel shortage has attracted attention to plastic tubular goods in recent months and plastic pipe has been put to use in several oil fields, two of which are mentioned in "Plastic Pipe," Page B-105.



Bigger and better drilling barges.

15. Drillstem Tests

"Use of drill stem tests, with improved tools developed by this branch of the industry, accounts for perhaps the largest percentage of success," reported the Doley Oil Company. "Wells, passed up as dry, have been reopened and proved commercially productive, by using the drill stem test before running the oil string. In one instance a geologist for a major company, after examining samples, failed to find encouragement, either from the time log, or from examination of samples. He ordered the drill stem taken, mainly because the well correlated favorably with a nearby producer, and the result 'amazed him,' to use his own words. A very good fillup of oil in drill stem proved the oil was there, in the lower zones of the Lansing lime. As the cost of this technique has been brought down to moderate price, this tool has done wonders for oil men here in Kansas. I would say its tops the best of methods that account for easier finding of oil. Even in cases where structure does not appear pronounced, oil may be trapped stratigraphically which cannot be detected easily except by running the drillstem tests."

16. Air or Gas Drilling

Use of gas or air as a circulating fluid in drilling can result in a substantial saving of time and money when used to drill through strata in which drilling mud is normally lost to the formation, Continental Oil Company stated in commenting on recent advancements. An important aspect of this saving is that it makes possible the drilling of wells, and the producing of oil and gas, in areas which otherwise could not be economically developed. Drilling equipment can be converted for the use of air or gas by the substitution of air compressors or gas supply lines in place of mud pumps. No special equipment is necessary. Especially has know-how or engineering progressed in this drilling method.

17. Fluid Drives

One of the drilling equipment advancements listed by Socony-Vacuum were fluid drives. The fluid drive has a transmission that may be considered shockless. Operations are generally smooth when this equipment is included in a draw works.

The introduction of the torque converter, which has the fluid drive principle, has increased the drive-power and efficiency of drilling rigs.

18. Safety Measures

Great studies have been made in accident prevention, as oil companies have increasingly realized safety as an important tool.

Accidents to operating personnel accounted for much lost production. In

addition, and very important too is the serious effect that some injuries have—the loss of a limb or an eye. Companies have organized meetings, classes, promotion, etc., to reduce accidents and make an oil field a safer place in which to work. Encouraging results have been obtained.

19. Aerial Surveying

Most answers to our inquiry concerning progress were concerned strictly with drilling and producing. Aerial surveying was listed, however, as an exploration advancement of great import.

Aerial photography has been used considerably in geological work since the last World War gave it a boost in techniques and equipment and plane adaptability. Contours can be plotted in great detail and much time is saved in surface geology. Aerial photography now can be accomplished from 800 ft to altitudes as high as 30,000 ft, according to specific requirements.

"I do not believe there is a single oil company in the world that is not using aerial photographs and maps made from them to speed exploration and development program."

Economics

Cities Service Petroleum pointed out that the proof of continual progress in improving the industry's techniques and equipment lay in the fact that petroleum products are being delivered today at prices (exclusive of taxes) comparable to or less than pre-war prices.

An observation from Socony-Vacuum touches a highly important subject—personnel. It has been said before that a good job can be done with poor equipment and good manpower or a much better one with good equipment and good manpower but you can't get a job done with poor manpower regardless of what kind of equipment you have.

Personnel

Socony said that all its operating personnel have been able to keep pace with the technical and design advances both in methods and equipment offered to the trade by manufacturers. This was accomplished by company training schools and by direct training of the individual in the operation.

It is well to remember that progress cannot go faster than operating personnel's ability to support it.

Conclusion

These marks of technical advancement are tremendous steps ahead. The industry can point to them with pride but cannot hold the pose very long because, as one company stated:

There are designs now on the drafting boards and applications of equipment not normally associated with the trade which potentially could obsolete the equipment and methods now being used.

What spurs this oil progress? Why come to the U. S. oil industry these miracles of invention and innovation of technique and equipment and of vision of greater ones in the future?

Oil progress—more perhaps than any other progress—is the result of economic freedom. Free men take the pulse of earth's potentialities with the artistry that no ancient slave or modern yes-man can acquire. Sometimes they have had to hold back the curtains of iron control while working frantically to meet demands of increased consumption and a wider range of products, but thus far they have achieved this, to the end that the humblest man today can purchase energy and comfort and protection that would be the envy of a king of yesteryear.

But progress knows no rest. What are you doing for us tomorrow?

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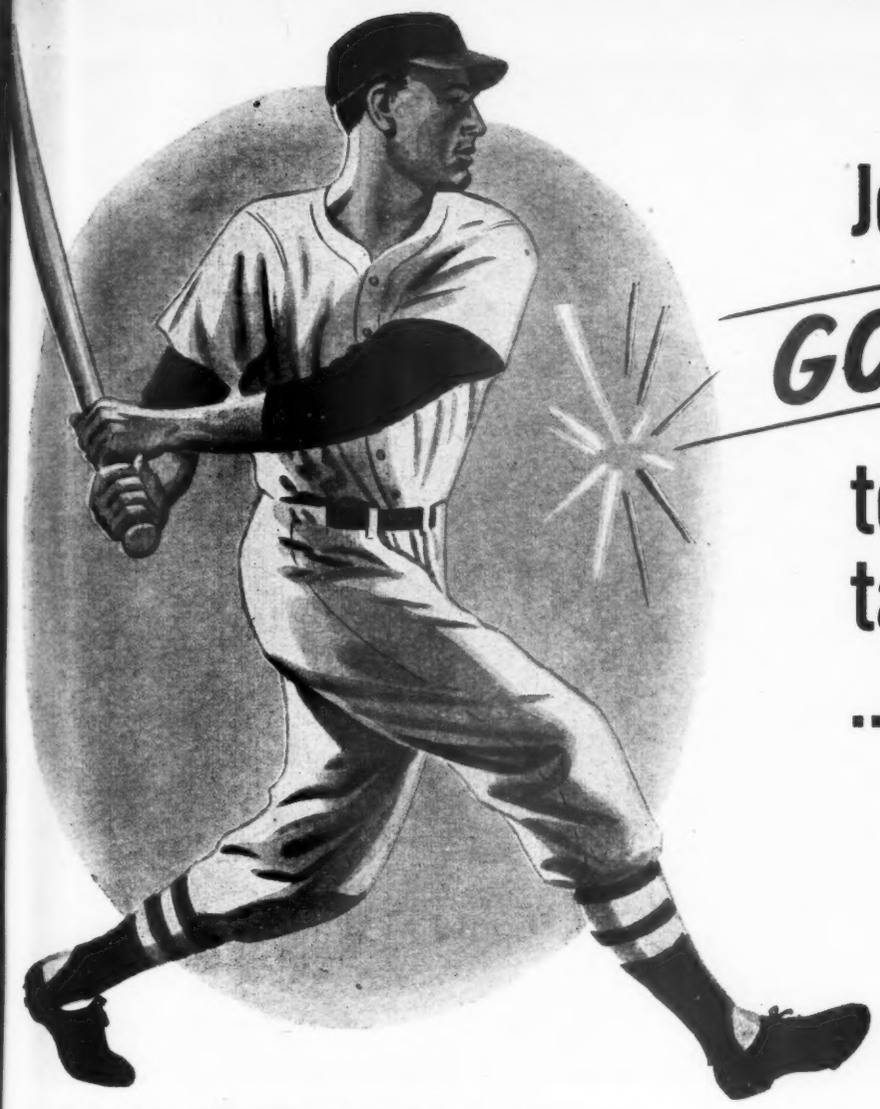

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to help your bits take a bigger cut ...make hole faster

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In crooked hole country, high-angle directional drilling, or when you encounter sloughing shale you can rally your mud "team" to a more effective performance by adding a pinch hitter — Jel Oil "E", ready-mixed oil compound which is easily added to conventional water base mud to give a stable oil emulsion mud.

Jel Oil "E" is not a substitute mud type for water base muds nor is it intended to be a mud conditioner for poor quality muds. Like the pinch hitter, it is essentially an improving agent for an already good drilling mud. Concentrations of Jel Oil "E" as low as 5% by volume of mud in the system have decidedly improved the performance of muds. Experience indicates that the optimum concentration of Jel Oil "E" to add at the time of conversion is 20% by volume of the finished mud.

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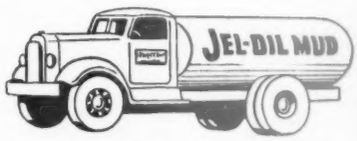

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Typical coastal area, very near to Puerto Limon, Costa Rica.

First Air Survey Made for Costa Rica

Union Oil hopes to outline sedimentary basin from extensive airborne magnetometer survey

Compilation of the aeromagnetic maps was completed within 60 days after flying was done.

A 2100-SQUARE mile air survey of the eastern coastal plains of Costa Rica has been completed recently by the Union Oil Company of California. The aerial photography and airborne magnetometer survey were done by Aero Service Corporation of Philadelphia. It is believed that it is the first extensive air survey made in Costa Rica.

The aerial photo coverage was obtained for the construction of base maps, and for the use of Union Oil's field exploration parties in plotting their data. Existing maps are inadequate for these purposes, and the air photos have been assembled in a radial plot to give a good reconnaissance picture of the area.

EXCLUSIVE

From the airborne magnetometer survey the company hopes to outline the sedimentary basin, judge the extent and effect of possible volcanics in the sedimentary basin, and secure an idea of the thickness of the sedimentary section involved. There is also the possibility of useful indications of localized structure being obtained from the aero-magnetic data, though this is not one of the primary purposes of the survey. It is known that the lava flows and the vulcanic intrusions in parts of the area covered give high gradient and complex magnetic figures. Thus the areas of igneous rocks

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Welex engineering research is continuously improving the effectiveness of TORPEDO-JET shooting and other Welex services. Better methods and equipment are important extras you get when you call on Welex for jet perforating services.

Ask your Welex service engineer about applications of the powerful, versatile TORPEDO-JET process in open hole shooting and other problems.

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EXTREME PENETRATION

LARGE HOLE DIAMETER

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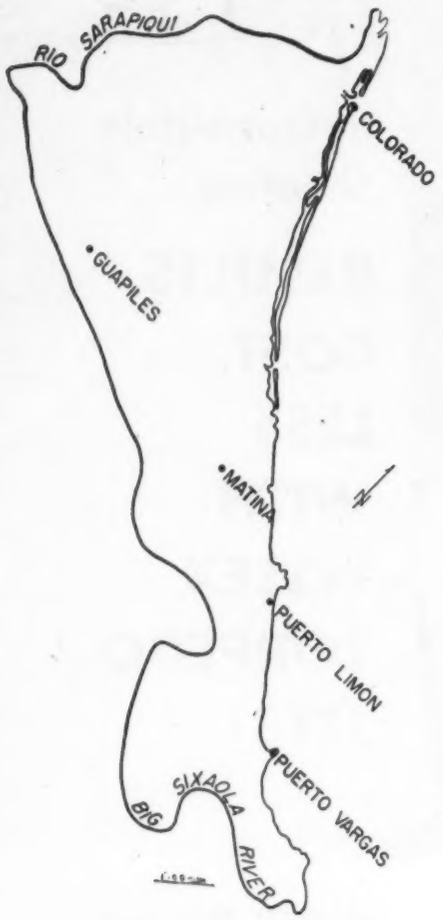
Diagram of the survey area, mapped with aerial camera and airborne magnetometer. The survey began in March, and was completed in June. Maps were delivered in August.



Photographer and pilot look over flight map before takeoff.

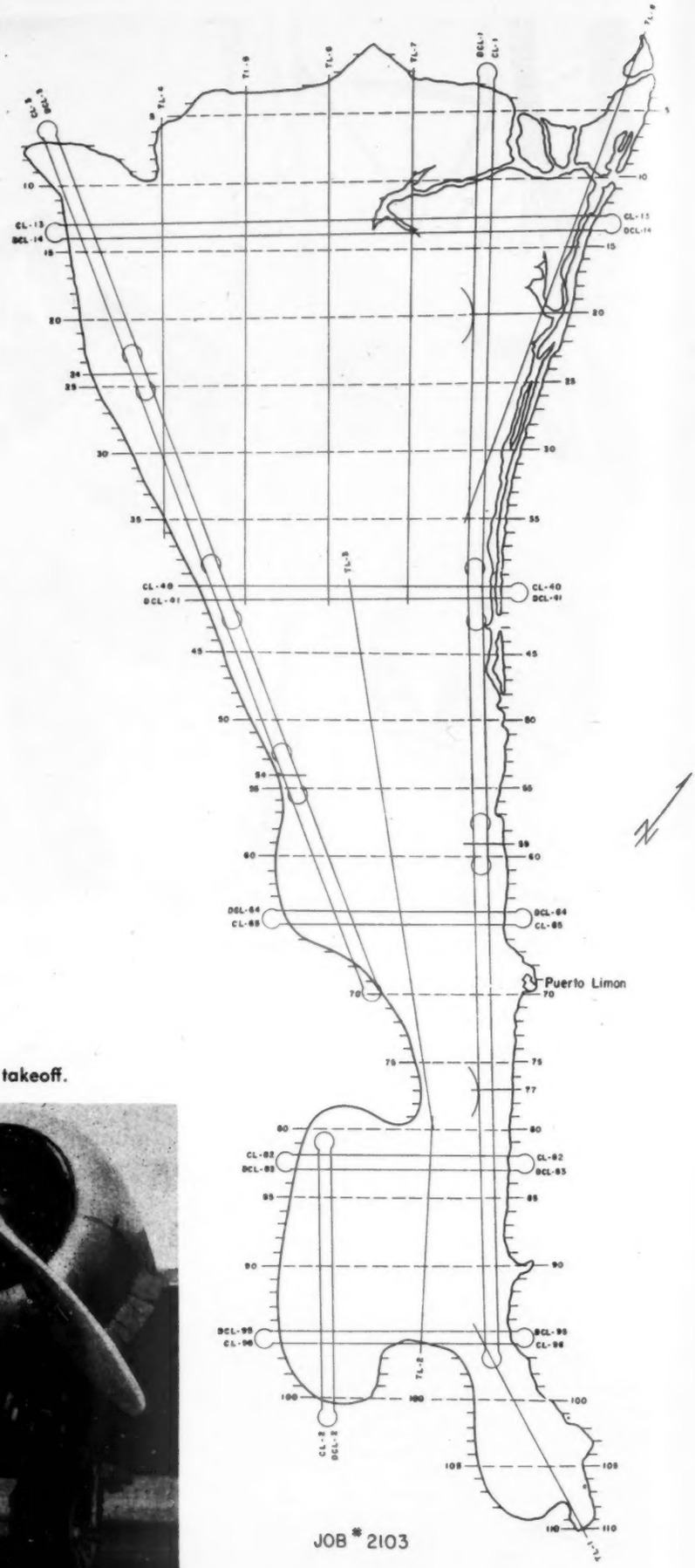


Diagram showing the flight patterns for the aeromagnetic survey of Costa Rica, executed for Union Oil Company of California by Aero Service Corporation, Philadelphia.

smooth destructive pressure peaks

ELIMINATE MUD LINE SHOCKS...

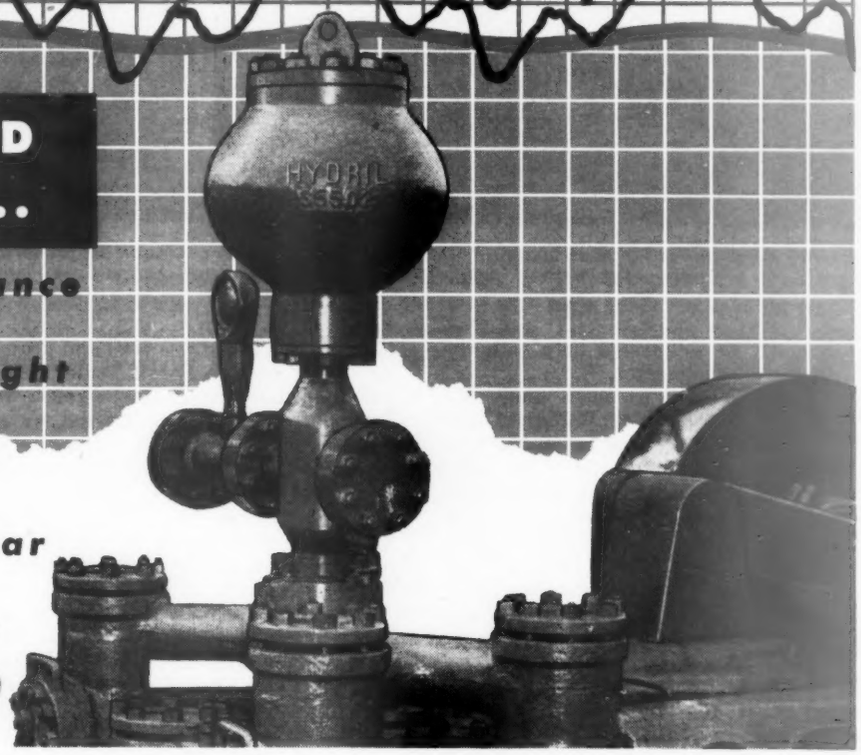
cut pump maintenance

keep pipe joints tight

lengthen hose life

reduce packing wear

increase efficiency



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4. **SELF-CLEANING**—Pre-charge pressure completely displaces fluid when pump is shut down. Sediment can't accumulate; maximum operating efficiency is assured at all times.
5. **LONG DIAPHRAGM LIFE**—Diaphragm moves freely from one end position to the other without undue stress and wrinkling. Provides maximum economical, trouble-free operation.

for complete information call or write

HYDRIL COMPANY

LOS ANGELES, CALIF. HOUSTON, TEXAS

Survey area, about 10 miles inland.

Mountainous terrain, 40-50 miles from coast.

can easily be delineated here with the airborne magnetometer.

The survey was executed under the direction of Newell F. Williams, resident manager of Compania Petrolera de Costa Rica, Ltda., an affiliate company of Union Oil. Nominal flight altitude was 2000 ft above sea-level. The diagram shows the flight control patterns, which provided for flight lines at right angles to the coast at a one mile spacing over the area. The control lines intersect the flight lines at right angles. The survey flights went inland almost as far as the 2000 ft elevations of the land. Existing photography, plus the aerial mapping were guides for the survey plane. The flight path was recorded with a continuous strip camera at a scale of $1'' = 2000'$ so that the plane's position throughout the survey could be reconstructed for the magnetic maps.

The twin engine survey plane* was flown to Costa Rica for the survey and a three man flight crew — pilot, photographer-observer, and magnetometer operator — were engaged in the survey. The aerial photo negatives, the strip camera film, and the magnetic data were processed by a two-man data staff.

*Beechcraft.

Charles Stinchfield was pilot and project chief and Eugene Borax, senior geologist loaned by Union to Petrolera for this purpose, was liaison for the survey.

In early March the survey crew landed in Costa Rica. Within 4 days they had flying weather, and the first aerial photo flight was made. Thereafter 66 flights were made at an altitude of 21,000 ft to obtain a total of 882 photos, all at a scale of 1:40,000.

The magnetometer survey flights began in May and were completed on June 6. Persistent rains and low clouds from the Caribbean slowed both the photomapping and magnetic work. Take-off for most flights was 6 in the morning, and work over the survey area often ended 3 or 3½ hours later because of fog, clouds, or rain. There was no weather station at the survey base in Limon, and the flight personnel had little need of it — one could be sure that almost any day there would be poor mapping weather before the day ended.

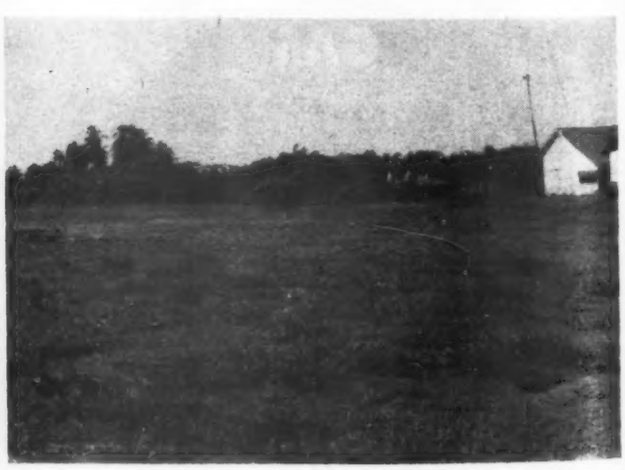
Though no ground station was maintained to record diurnal variations, the magnetometer was operated for some while before take-off as a safeguard against magnetic storms. No serious storms were observed during the March-June survey period, and it has been found that in general the equatorial areas offer little trouble in this regard.

The survey instrument was a high sensitivity Gulf airborne magnetometer Variations in magnetic intensity as small as one or two gamma (or 1 or 2 parts in 50,000) were recorded. The magnetic data were compiled in contour maps at a 10 gamma contour interval, and the completed maps were delivered 60 days after flying was finished. Oil company geologists will study and analyze the maps as part of the broad exploration being carried forward in Petrolera's concession in Costa Rica.

Weather was the only serious operational problem, and as is customary it was taken into account by the survey contract, which provided for a charge for the unit of work, plus a fixed charge for standby time for the plane and flight personnel.

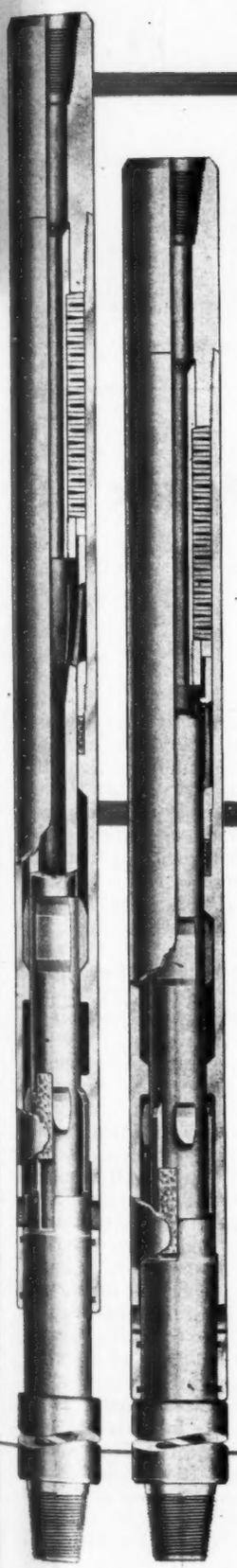
The survey's progress was substantially expedited through the cooperative attitude of the Government of Costa Rica. Officials readily cleared the survey plane and crew for entry into the country, and they helped in a number of ways to smooth the path of the survey group. ★ ★ ★

Quarters for air survey crew at Limon.



Limon airport, Costa Rica, was base for survey.

No Wonder the Shaffer-Waggener Bumper Safety Joint is Revolutionizing Today's Drill String Protection!



Locked Position

Tripped Position

THE ECONOMY AND SAFETY OF 2 TOOLS IN 1

backed by performance records like these . . .

▶On California's deepest well, a Shaffer-Waggener Bumper Safety Joint running in the drill string just above the drill collars, proved invaluable in recovering the drill string from a depth of 18,136 ft. When the string became stuck, only 2¾ turns of back torque were required at the table to release the Safety Joint portion of the tool, permitting immediate recovery of all drill pipe. Fishing jars were then placed in the recovered string, with the recovered portion of the Bumper Safety Joint on bottom, and this string was run back into the well. The tool was easily reconnected to the Safety Joint portion on the fish, and after jarring the drill collars and bit loose, the entire string was recovered—*from approximately 3½ miles deep*—leaving a completely clean hole!

▶On another well a Shaffer-Waggener Bumper Safety Joint was in the string between drill collars and drill pipe when the string parted going into the hole, dropping over 2,400 ft. of pipe and drill collars 5,000 ft. to the bottom of the well at 16,883 ft. First, the top of the fish was gripped with a socket and the Bumper Safety Joint released, permitting immediate recovery of 2,100 ft. of drill pipe. Then the upper part of the Bumper Safety Joint was run back into the hole below a set of jars, reconnected to the lower part of the Bumper Safety Joint and—after jarring—the drill collars were completely recovered *from over 3 miles deep*, leaving the hole completely clean!

▶Besides operating successfully at even great depths, this tool takes slant holes in stride—has been used efficiently in extreme directionally-drilled wells with a slant of 60°!

In fact, on job after job—from the shallowest to the deepest—the Shaffer-Waggener Bumper Safety Joint is bringing entirely new standards of safety, efficiency and protection to modern drilling operations!

Combines 2 tools in 1

The Shaffer-Waggener Bumper Safety Joint is the *only* tool of its kind—the ONE tool that combines BOTH *jarring* and *releasing* action—each under the full control of the operator. And not only does it combine in *one* tool the protection usually requiring several tools, but it also provides advantages *found in no other single tool or combination of tools!*

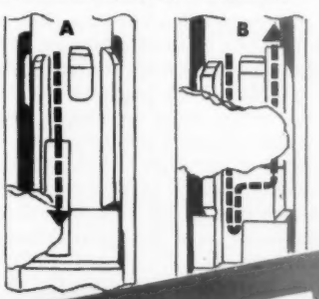
Check These Advantages . . .

To use the tool as a Bumper Sub it is only necessary to slack the weight of approximately 2000 ft. of drill string upon the Bumper Safety Joint, thus actuating a tripping mechanism which trips *automatically*, allowing the tool to strike a sharp downward blow. Raising the string then *automatically* resets the tool for another blow—and blows can be struck repeatedly and continuously by simply raising and lowering the drill string. It's simple, positive, *automatic!*

To use as a Safety Joint for quick release in the event the stuck pipe cannot be loosened, simply trip the tool and apply left torque as the string is slowly raised (A). The reverse torque rotates the drive keys into an unlocking slot (B) so that, by simply continuing to raise the string, complete release is effected. Further, the recovered portion of the tool can be used on the bottom of a fishing string and easily reconnected to the portion in the hole for simplified recovery operations.

As a Safety Joint the tool will not release until it is tripped. Therefore, it will transmit full torque loads in *either* direction—a definite advantage over conventional Safety Joints.

Two tools in one means simplified maintenance, simpler design, plus substantial savings in operating costs.



The many vital advantages of this revolutionary tool are too numerous to cover here, but are described in detail in an eight-page bulletin we will gladly send you. Write today!

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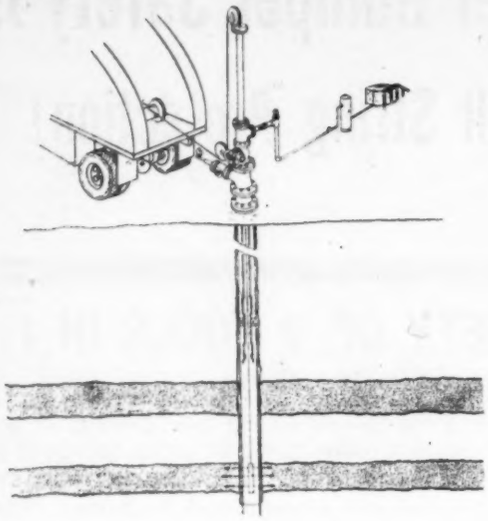

FIG. 1. Permanent-type well completion.

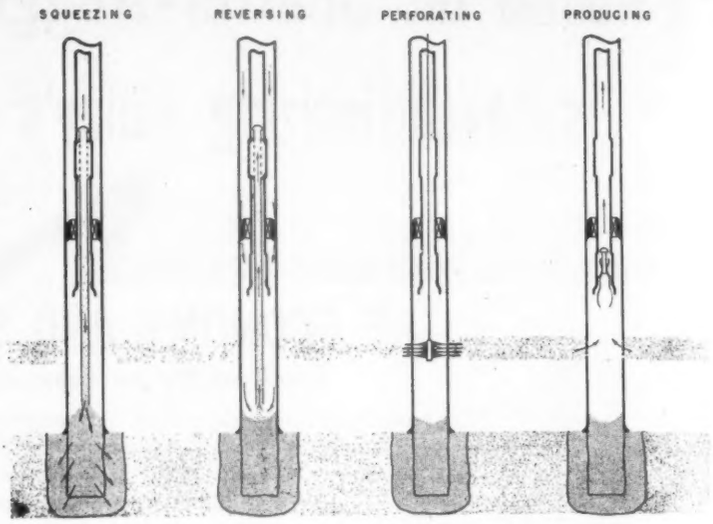

FIG. 2. Use of wire line retrievable tubing extension.

Well Completion and Remedial Work

Rig time is saved and cost of workovers reduced by new method of permanent-type completion

ENCOURAGING progress has been made in the development of a new type of well completion that greatly decreases the cost of completions and workovers and aids in the acquisition of reliable reservoir information at low cost. The completion and remedial operations are performed with tools passing through the well tubing. Wells can be perforated and plugged back with the tubing in place and without pipe-handling equipment. This new type completion has made possible the saving of one to two days' rig time in the completion of each of several hundred wells during the past two years and use of equipment developed for this type of completion has resulted in a 75 per cent reduction in cost of certain types of workovers. In addition, more reliable indications of the commercial value of a reservoir and more accurate general reservoir information obtained through the new type of completion promise to be of considerably more value in oil recovery than the reduction of cost for completions and workovers.

The first instrument specifically designed for permanent-type well completion was the tubing-type perforator. The use of this small perforator with a permanent well setting is shown in Fig. 1. The tubing-type perforator presently used is 1¾-in. OD and employs 5 jet charges per foot. These jet charges fire at an angle of 45 deg from the horizontal and are contained in a self-destructible aluminum carrier. As the gun carrier is self-destructible, the gun may be of any convenient length desired. The longest continuous interval thus far perforated with one gun was 31 ft and the gun contained 155 shots. This tubing-type perforator has been used several hundred times with excellent results. It has proved to have sufficient penetration when perforating various size pipes from 3-in. liner through 7-in. casing.

The tubing-type perforator has been run on standard 7/16-in. monocables from standard shooting trucks but experiments are being conducted with a small panel shooting truck and a 3/16-in. stranded steel single-conductor line. A magnetic casing collar locator is run with the perforator and is capable of locating any change in the density of metal in the tubing, casing, or liner.

When completing the well, the tubing is set above the possible producing zone and drilling mud is displaced with a clean formation fluid. The Christmas tree is placed on the well and sufficient fluid is removed from the well to reduce the hydrostatic pressure exerted by the well fluid to less than the formation pressure; this will provide a differential into the well bore. This use of clean fluid and a pressure differential into the well bore should eliminate the partial or complete plugging of perforations. Prior to perforating a new well, the drilling rig is removed and a smaller type of handling equipment is used to support the sheave for the shooting line. It is possible to run tubing while allowing cement to set and the over-all time saving will generally be one to two days per well.

Many workovers are performed on wells where only the re-perforation of the old producing interval or perforation of additional interval is involved. If the bottom of the tubing is above the desired producing interval, the tubing-type perforator makes it possible to perform any additional perforating or re-perforating without removing the tubing or using a workover rig.

Recently, several wells have been successfully plugged back with cement and re-perforated in a higher interval without the use of a drilling rig. These wells contained constant flow gas lift valves having chokes with reverse checks. Formation salt water was used as a workover fluid during the entire operation of cementing and re-perforating. A retrievable tubing extension was used to change the effective length of the tubing during the cementing operation. As can be seen by Fig. 2, these wells contain squeeze packers, that permitted high squeeze pressures but did not prevent the excess cement from being reversed out of the tubing or extension. A swab truck was used to lower the tubing extension into place prior to cementing operation and to retrieve the tubing extension after cementing, thus eliminating the use of pipe-handling equipment.

As development work continues it may soon be possible to perforate and cement the majority of wells without removing the tubing. It will be possible in the future to complete new wells and to perform remedial work on existing wells without the use of pipe-handling equipment, drilling mud, mud pits, and other complementary items that create excessive workover costs. ★ ★ ★

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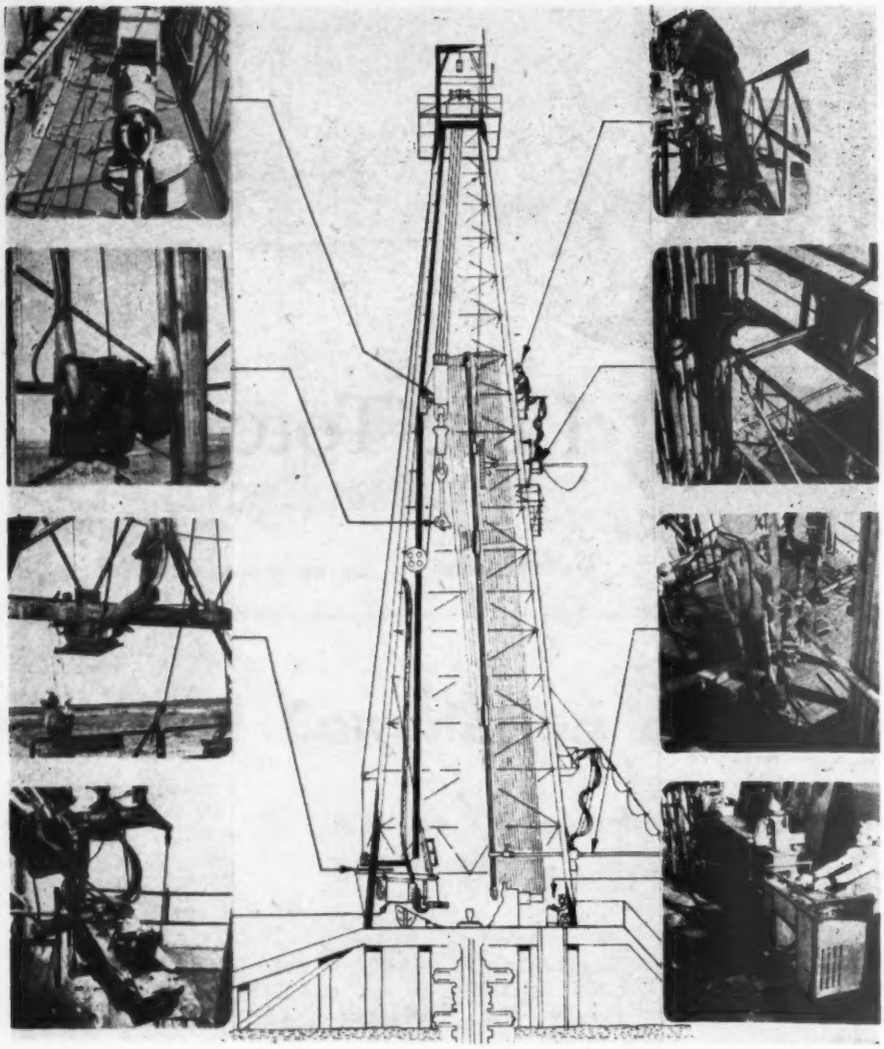

FIG. 1. Semi-automatic power-operated drilling rig.

Semi-automatic

Power-Operated Drilling Machinery†

MARTIN E. TRUE

To provide means for eliminating much of the fatigue and many of the hazards on the part of drilling crews in making round trips, an improved type of semi-automatic, power-operated drilling machinery has been developed, after years of research and field testing, which permits round trips to be made without drill pipe being touched by hand. One unit of the latest design of this equipment, which is the outgrowth of the original set of the semi-automatic equipment recently field tested, is currently in field service. The equipment consists of hydraulically- and pneumatically-operated tongs which perform the spinning and tonging operations, and the pneumatically-operated racking units mounted in the derrick for carrying the pipe to and from the center of the hole and positioning it on the mat and in the rack. With this equipment, all of the operations of the various units are controlled remotely by manipulation of hydraulic and pneumatic valve levers.

†Presented before the Spring Meeting of the Pacific Coast District, Division of Production, American Petroleum Institute, Biltmore Hotel, Los Angeles, California, May 15 and 16, 1952.

A GREAT amount of work has been done to increase the speed and efficiency of drilling operations and to reduce the fatigue of rig crews. As a result, automatic and semi-automatic, powered equipment is being used to perform more of the routine operations encountered in drilling wells. Air slips have found wide acceptance throughout the drilling industry and automatic drilling, or feed-off, controls as well as air brakes are gaining favor. Now, after several years of research and field testing, equipment has been developed which permits making round trips with drill pipe with only the expenditure of the effort required for actuation of controls. One complete set of remotely-controlled, power-operated drill pipe tongs, spinner, stabber, pipe rackers, elevators, and traveling block deflector has been manufactured and is currently in field service. The latest design of this equipment is the outgrowth of the original set of the semi-automatic equipment field tested in the Gulf Coast area of Texas during 1948 and 1949. The original experimental semi-automatic equipment, described in a previous paper,[1] which was used for drilling approximately 75,000 ft of hole over a period of 18 months, was similar in many respects to the latest models and served as a basis for the final design.

Remotely-controlled, hydraulically-powered tongs, which are suspended from a telescoping arm clamped to a derrick leg, perform the spinning and tonging operations and assist in stabbing the pipe. Single stands of pipe, before becoming a part of, or upon being removed from the string of pipe in the hole, are supported and positioned by semi-automatic, powered machinery, independent of the main hoisting equipment. This work is performed by an auxiliary mounted near the top of the derrick, and an upper and lower racker, mounted between the tenth and eleventh girts and above the first girt, respectively. The hoist supports the weight of the stand and provides for vertical movement, while mechanical "arms" and "hands" on the two rackers guide the pipe to its proper position. Opening of the main pipe elevator is controlled by an operator on the derrick floor by means of compressed air, and closing is accomplished by a trigger which, on

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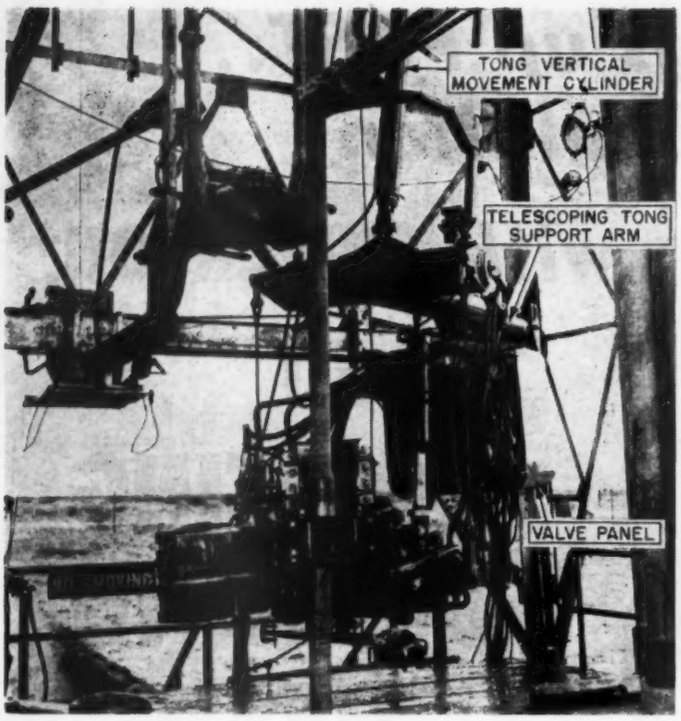

FIG. 2. Power tongs and valve panel are suspended from a telescoping arm attached to a leg of the derrick. All movements of the tongs are controlled remotely.

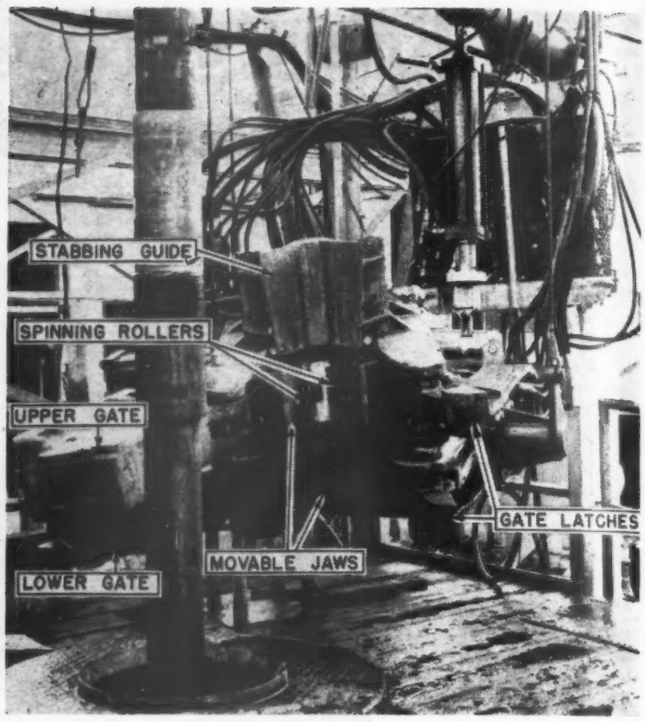

FIG. 3. Spinning rollers are extended hydraulically and driven by air motor. Pipe is gripped for tonging by dies on movable jaws, also extended hydraulically.

contacting pipe, holds the elevators open and springs compressed. To permit simultaneous movement of the traveling block and of the auxiliary equipment handling a single stand of pipe, a traveling block deflector has been provided; thus, the traveling block can make a trip up or down along the side of the derrick, without a load, while a stand of pipe in the center of the derrick is being made up or broken out, and idle time of all the equipment is appreciably reduced.

Most of the physical effort in making round trips with drill pipe has been eliminated in that all operations of tonging, spinning, stabbing, and racking of pipe on the floor are controlled by operators in a seated position by manipulation of hydraulic and pneumatic controls. The driller is relieved of operating the cathead, leaving only the hoist and slips to be controlled.

Safety is substantially improved, as a derrickman performs his duties by manipulating a single "joy stick" control on the working platform, and the conventional spinning chain and tong lines are removed from the derrick floor. The hazards and manual labor encountered in moving drill pipe to and from the racking position and in stabbing are also eliminated.

It is possible to maintain the high rate of handling pipe with this equipment for long periods whereas fatigue slows crews working conventionally during round trips, especially under adverse weather conditions. After completing round trips with this equipment, drilling crews are not exhausted; consequently, they are able to perform their duties effectively while drilling, which is essential for maximum overall efficiency.

Fig. 1 is a drawing of a derrick equipped with the power-operated drill pipe handling equipment.

Power Tongs

The hydraulically-operated power tongs are suspended from a telescoping arm clamped to the derrick leg, as shown in Fig. 2. The arm is pivoted at the derrick leg to permit vertical, as well as horizontal, movement of the tongs. Vertical movement is effected by a hydraulic cylinder, one end of which is attached to the tong end of the support arm, and the other end to a cable attached to the derrick leg at a height of 60 ft above the derrick floor. The tong movement to and from the center of the hole is accomplished by a hydraulic cylinder within the telescoping arm.

The Author

Martin E. True is co-ordinator of equipment research in the petroleum engineering division of Humble Oil and Refining Company. He is a member of the API and AIME. He received the BS degree in mechanical engineering from Texas Technological College in 1938. He joined Humble immediately after graduation and shortly thereafter became associated with the production research division where he served until 1945, from which date he has been engaged in equipment research.

The tongs, shown in Fig. 3, consist of two pipe gripping units, one mounted directly above the other. Make-up or break-out with the tongs is accomplished by a scissor action produced by a hydraulic cylinder connecting the outer ends of the tong frames. Fig. 3 shows the tongs in the scissored position, which is automatically assumed when they are set for making up tool joints. The tong frames are parallel to each other when set for breaking tool joints. Each tong is provided with a hydraulically-operated gate and latch, as shown in Figs. 2 and 3, which are actuated by a control lever having a dual function on the remote control panel. The same lever controls the movement of the tongs to and from the center of the hole.

The jaws of the tongs, shown in Fig. 3, are essentially "V" blocks containing dies. In order to effect the gripping force necessary to perform the tonging operation, they are moved with respect to the tong frames in the direction of the gate by hydraulic pressure applied to cylinders attached to the rear of the jaws. The upper tong is provided with a pair of serrated rollers which are extended beyond the face of the dies in the tong jaw by hydraulic pressure for engaging the pipe to produce the spinning operation. These rollers, which are six inches in diameter and capable of a speed of approximately 100 rpm, are powered by an 11-horsepower reversible air motor driving through reduction gears, sprockets, and roller chains. A third, smooth roller acts as an idler and is located in the gate of the upper tong. It, likewise, is extended hydraulically and holds the drill pipe tool joint clear of the gripping dies while spinning.

After a tool joint has been shouldered

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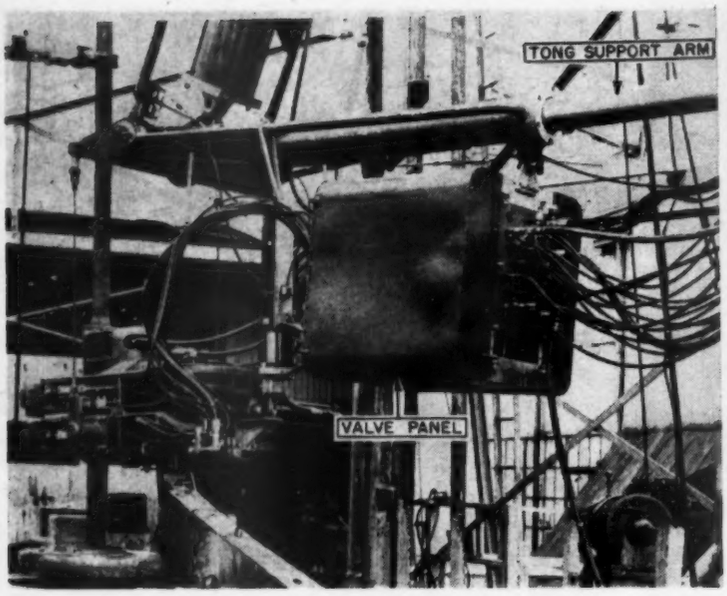

FIG. 4. Valve panel for power tongs. Lines leading from rear of panel are hydraulic and air supply lines and pilot control lines extending to the remote control panel.

FIG. 5. From remote control panel the operator controls all movement of tongs and lower racker and vertical movement of the single-stand elevator.

by the spinner, the final tightening of the joint is accomplished by scissor action of the upper frame. The tongs are capable of gripping pipe ranging in size from 2⅞-in. tool joints (3¾-in. OD), up to and including 8-in. OD drill collars. Each of the tongs can exert a gripping force of approximately 400,000 lb and can develop a maximum make-up torque of 41,000 ft-lb and a break-out torque of 120,000 ft-lb when the hydraulic system is operated at a pressure of 2500 psi. The make-up torque of the tongs is controlled to any predetermined value by regulating the hydraulic pressure entering the actuating cylinder which produces the relative motion of the tongs.

The various operations of the hydraulic tongs, spinner, and supporting arm are controlled by pneumatic and hydraulic valves in the panel mounted in back of the tongs and below the strong supporting arm, as shown in Fig. 4. The lines leading from the rear of the panel are the hydraulic and air supply lines and the pilot control lines extending to the remote control panel, shown in Fig. 5. This remote control panel is located at a convenient position on the edge of the derrick floor to allow the operator a full view of the various operations.

Remotely Controlled Pipe Rackers

The pipe racking system consists essentially of two carriages, one mounted on horizontal tracks just above the first girt and the other on horizontal tracks between the tenth and eleventh girts, each of which supports a pneumatically-powered arm equipped with a "mechanical hand." Each arm, which is constructed of 3-in. diameter tubing, is capable of extending into the derrick a distance of approximately 18 ft. Two air motors mounted in each carriage drive the carriage and the arm through a mechanism similar to a rack and pinion. Two roller chains, one stretched parallel to the carriage tracks, and one fastened immediately below the arm, pass through each carriage. These chains are engaged by sprockets driven by the air motors, and thus each carriage can be moved along the side of the derrick on its tracks and each arm can be extended and retracted through its carriage. The roller chains for the upper racker may be seen in Fig. 6.

Upper Racking Unit

The upper racking unit is shown in Fig. 6. On the end of the racking arm is a vertical track which guides a single-stand elevator. This elevator consists of a "U"-shaped member capable of gripping and supporting a 90-ft stand of drill pipe. Vertical movement of the elevator and the lifting force required to support a stand of pipe are obtained by means of a pneumatic cylinder mounted just below the water table and connected to the elevator by a wire line. This power cylinder is controlled from the remote panel on the derrick floor. The elevator is equipped with a hydraulically-operated, spring-opening claw for supporting the pipe and with teeth on one side of the "U" for backing up the pipe while rotating out with the rotary table. A "pullback" system of cable and blocks for deflecting the single-stand elevator hoisting line is provided for producing an upward force on a stand of pipe to jump the pin out of the box as a joint is broken. Power for the "pullback" is supplied by an air

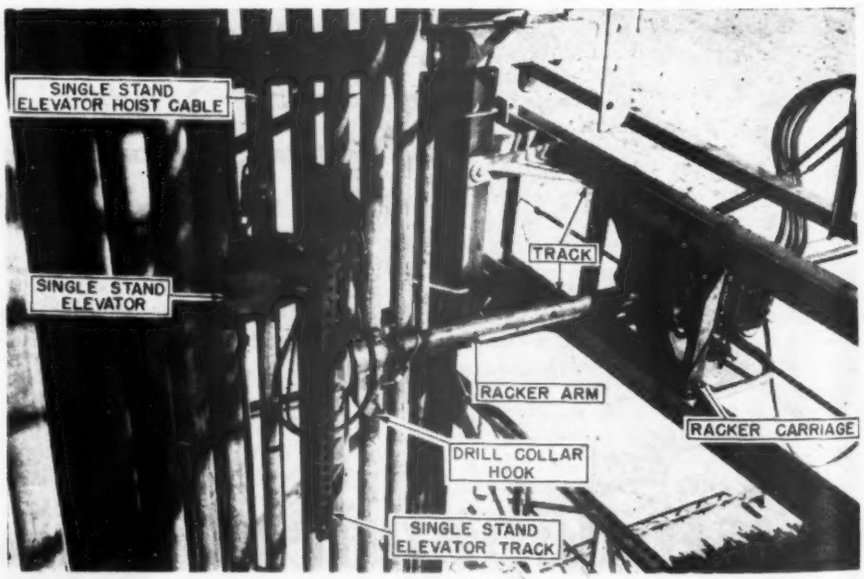

FIG. 6. Upper racker. Single stand elevator grips and supports stand of drill pipe as it is moved by the racking arm into pipe rack. Elevator will lower pipe to mat before releasing.

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Regular Size Safety Clamp (Type CR), above, fits diameters 3¾" to 10⅝". Large Size (Type CL) fits diameters 11½" to 15½". Extra Large Size (Type CXL) fits diameters 15½" to 21". Tubing Size (Type T) fits diameters 1⅛" to 4½".

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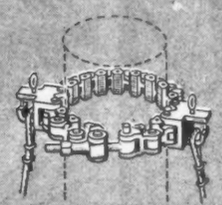

FOR SNUBBING drill pipe and tubing, the Safety Clamp is simply inverted so the slip segments pull down instead of up. Easily-attached hold-down ears permit fastening anchoring cables with maximum speed and simplicity.

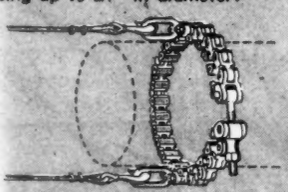

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FIG. 7. Derrickman operating upper racker. The derrickman also controls the claw on the single-stand elevator. Raising and lowering pipe racking fingers are the only manual operations required of him.

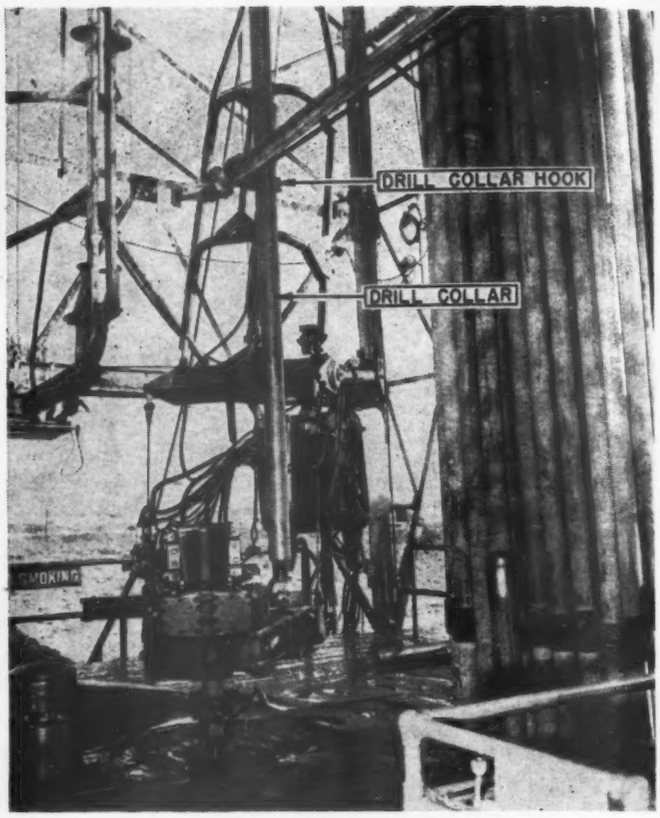

FIG. 8. Racking drill collars. Hook on lower racker arm is used for moving drill collars to and from the pipe mat. The tongs are set for stabbing.

ELEVATOR TRIGGER
AIR OPERATED ELEVATOR
LOWER RACKING ARM CLAW
DRILL COLLAR HOOK
CONTROLS FOR AIR OPERATED DRILL PIPE ELEVATOR AND TRAVELING BLOCK DEFLECTOR
STABBING GUIDE
TONGS SCISSORED, GRIPPING JAWS RETRACTED, GATES CLOSED

FIG. 9. Stabbing drill pipe. With the tongs in position on the tool joint box and with the tong gate closed, the stand of pipe is moved into stabbing position by the racker and lowered into the box by the single stand elevator hoist.

FIG. 10. Traveling block deflector rail. Deflecting the traveling block while it makes empty trips greatly reduces idle time of traveling block, racking equipment, and tongs. The vertical portion of the rail is 6 ft from the center of derrick.

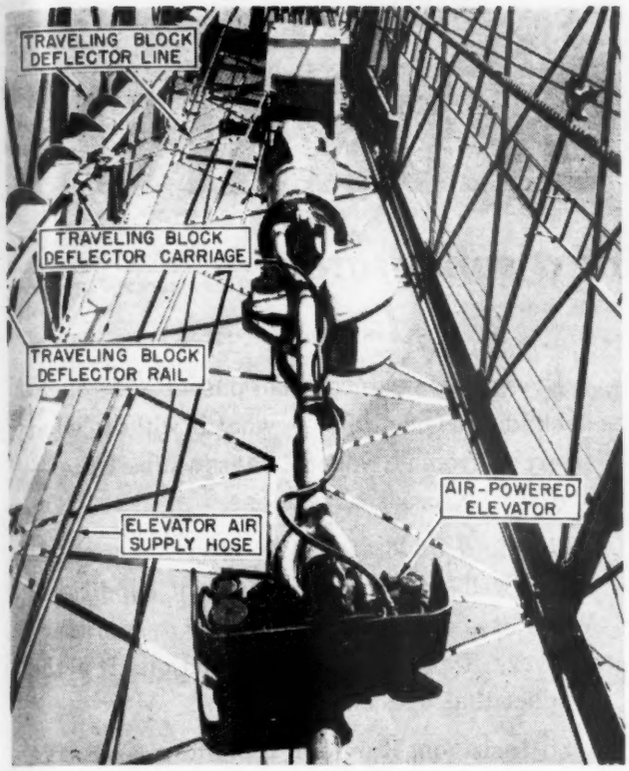

FIG. 11. Handling a load with the main hoist equipment. The block is in its center position. It is deflected by shortening the deflector line, which shortens the running loop between the deflector carriage and the block.

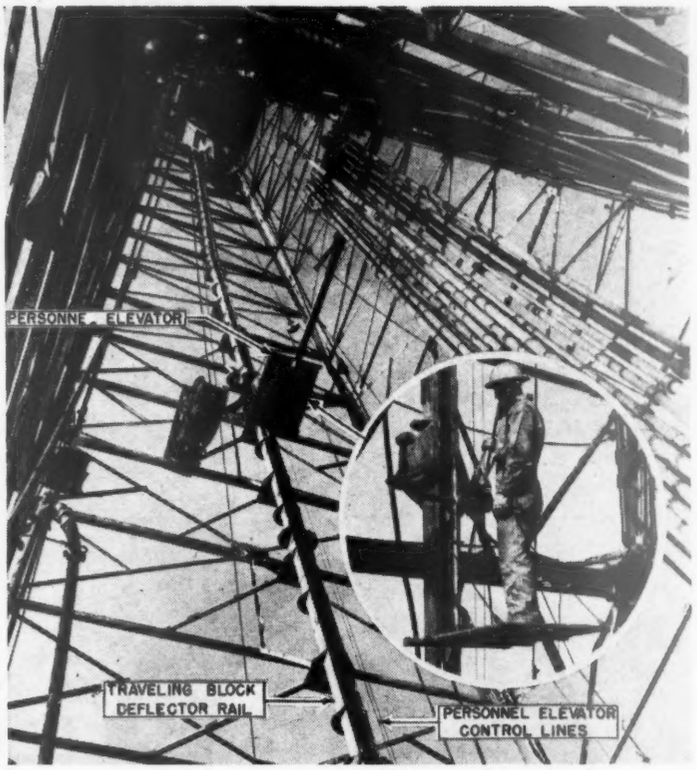

FIG. 12. Personnel elevator and casing stabbing board. The personnel elevator is guided by the deflector rail and powered by an air winch. Besides serving as an elevator for the derrickman, it is a convenient working platform at any height.

cylinder mounted in the same assembly as the single-stand elevator hoist cylinder. Fig. 6 shows the elevator at the top of the track immediately after lifting a stand of pipe at the center of the derrick and carrying it to the racking position, and prior to lowering it to the pipe mat.

Conformation of the single-stand elevator to leaning pipe is provided for in one plane by a pivotal mounting of the track on the end of the arm and in the other plane by a hinge between the elevator and its carriage. Control of the upper racker for positioning the pipe is obtained through a single "joy stick" operated by the derrickman from either the platform outside the derrick, as shown in Fig. 7, or from the conventional platform inside the derrick.

For handling drill collars, a heavy duty hook is provided immediately behind the single-stand elevator track, as shown in Fig. 6. This hook is rotated into a horizontal position for handling collars and is equipped with rollers to facilitate vertical movement of the collars.

Lower Racking Unit

The lower racking unit, located immediately above the first girt, is similar to the upper racker, differing mainly in that the end of the racking arm is equipped with an air-actuated claw which encircles the drill pipe. The claw is constructed to permit vertical movement of a stand of pipe while it is being guided. This unit is likewise equipped with a heavy duty drill collar hook, as shown in Fig. 8, mounted on the arm immediately behind the claw in such a manner that it can be pivoted about the arm into a horizontal position by actuating a latch. When the hook is not in use, it is latched in a vertical position, as shown in Fig. 9. The lower racker is controlled by the tong operator through the master control panel.

Traveling Block Deflector

During the initial phase of field testing of the original power tongs and racking equipment, it was noted that the auxiliary pipe handling equipment was idle during the time the empty traveling block was ascending or descending. In that the block moved through the center of the derrick, it was necessary that it reach the top of its travel before a single stand could be stabbed and made up with the auxiliary equipment. Also, it was necessary for the block to remain at the top while the last stand removed from the hole was broken, rotated out, and moved to the racking position. This led to the development of apparatus and a system for moving the block away from the center line of the hole when it is traveling empty.

The traveling block deflector equipment consists of a rail which is attached to and extends vertically up the side of the derrick until it contacts the derrick at the twelfth girt, and from this point to the top, is parallel to the side of the derrick, as shown in Fig. 10. The vertical portion of the rail is six feet from the center of the derrick. The lower section of the rail is hinged at a point ten feet above the floor to permit it to be fastened to the first girt in a horizontal position, as shown in Fig. 2. The lower end of this hinged section of the rail is equipped with an air hoist which controls the movement of a wire line running up the outside of the derrick and passing over a sheave at the upper end of the deflector rail. The line extends down the inside of the derrick parallel to the rail and passes through sheaves on a carriage riding the rail and a sheave attached to the side of the traveling block, as shown in Fig. 11. The end of the cable is anchored to the bottom of the rail, and deflection of the block is effected by shortening the cable. Fig. 11 shows the traveling block in the nondeflected position while handling the drill pipe load, and the small carriage and cable system which follows the movement of the main block. Fig. 10 shows the traveling block moving up the side of the derrick in a deflected position as the stand of pipe is being made up with the auxiliary apparatus.

Air-Operated Drill Pipe Elevator

The air-operated elevator is a standard, heavy duty elevator which has been converted by adding air cylinders for releasing the latch and for opening, and at the same time compressing springs located on the back side, and setting a trigger mounted on the upper portion of the elevator. The trigger, on contacting the drill pipe, is automatically actuated to permit the springs to close the elevator around the pipe. Fig. 9 shows the elevator in the cocked position, and the trigger mechanism which holds the elevator open. Fig. 11 shows the power elevator latched around, and

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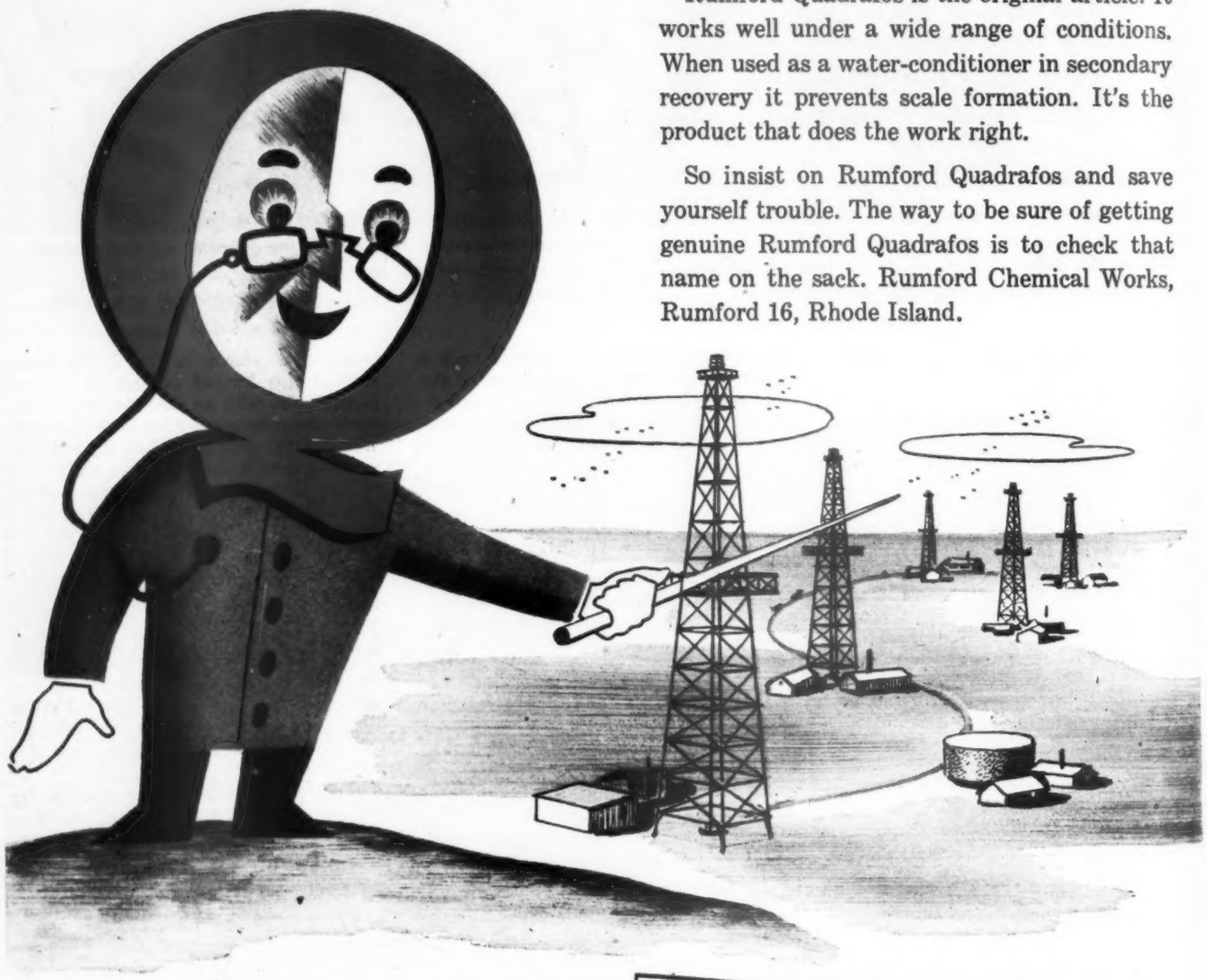

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hoisting, drill pipe. Air is supplied to the power elevator by hose wound on a reel, with the end being attached to the hook body. The reel, which is mounted in the derrick as shown in Fig. 10, is approximately 50 ft above the derrick floor and is equipped with an air actuator which maintains tension on the hose as the block moves up and down. The air-operated elevator is controlled remotely by the operator on the derrick floor by the manipulation of an air valve.

In coming out of the hole, as soon as the drill pipe is set on the slips and the upper racker engages the drill pipe, the operator on the floor applies air pressure which releases the latch and opens the elevator to a cocked position. As soon as it is cocked, air pressure is released, which allows the elevator to automatically close when triggered. In going in the hole, the same general procedure is followed by the operator on the floor. The horizontal motion imparted to the elevator by the traveling block deflector provides the necessary motion for engaging and disengaging the drill pipe without the necessity of manual guiding.

Controlled Semiautomatic Pipe Handling Equipment

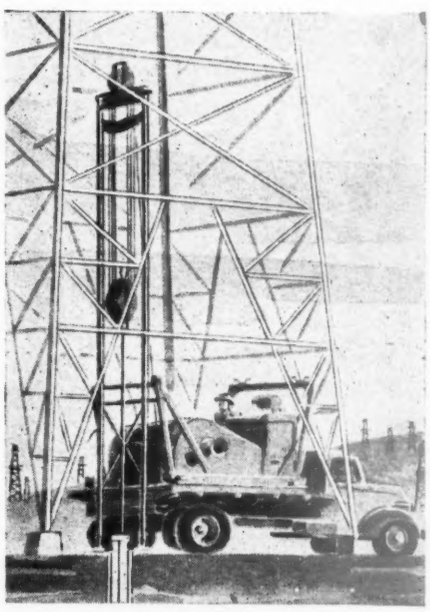
All of the movements of the upper end of the drill pipe are controlled by the racking arm, the derrickman's only manual operation being to lower the racking fingers in coming out of the hole and to raise the racking fingers when going in the hole. In addition to controlling the racking arm, the derrickman controls the opening and closing of the claws in the single-stand elevator. All of the tonging operations and the pipe handling on the derrick floor are controlled remotely from a stationary console on the edge of the derrick floor, by an operator in a seated position. Gripping and subsequent raising and lowering of the single stand are also controlled by the tong operator. One additional man is engaged on the derrick floor in doping tool joints and in actuating the traveling block deflector and power elevator controls, shown in Fig. 9.

Coming Out of the Hole

By the time the slips have been set, rackers are placed on the drill pipe. Immediately thereafter the main elevator is released and the traveling block is deflected off center and begins lowering, as shown in Fig. 10. The tongs move into position around the pipe and both upper and lower tongs grip and are scissored to break the joint. The tongs are then released and start retracting as the single-stand elevator on the upper racker grips the pipe and serves as a backup while the rotary table spins the string of pipe in a clockwise direction. After the control is actuated to effect the grip of the single-stand elevator, a sequence valve is energized which actuates the single-stand elevator hoist line pull-back, producing a pre-set force for jumping the pin out of the box as soon as the tool joint is spun out. While the breaking and spinning out are being accomplished, the traveling block has been lowered in the deflected position and as soon as the elevator reaches a predetermined point and the single stand has been removed, the block deflector is released, allowing the elevator to automatically latch around the pipe in the hole. While the next stand is being hoisted, the rackers and single-stand elevator move the single stand of pipe to the pipe mat and racking fingers, and then return to a central position ready to receive the next stand of pipe.

Going in the Hole

When going in the hole, the single-stand elevator is set at the bottom of its track. The upper and lower rackers engage and pick up the stand of pipe from the mat and racking fingers and move it to a position just clear of the traveling block while the previous stand made up into the string is lowered into the hole and set on the slips. The main elevator is opened and deflected off center by the traveling block deflector as it starts rising, as shown in Figs. 2 and 9. The operator then moves the next stand of pipe, being supported by the rackers, to the center of the derrick and at the same time moves the tongs up to the tool joint box set above the rotary and closes the tong gates, as shown in Fig. 2. The chute mounted on and above



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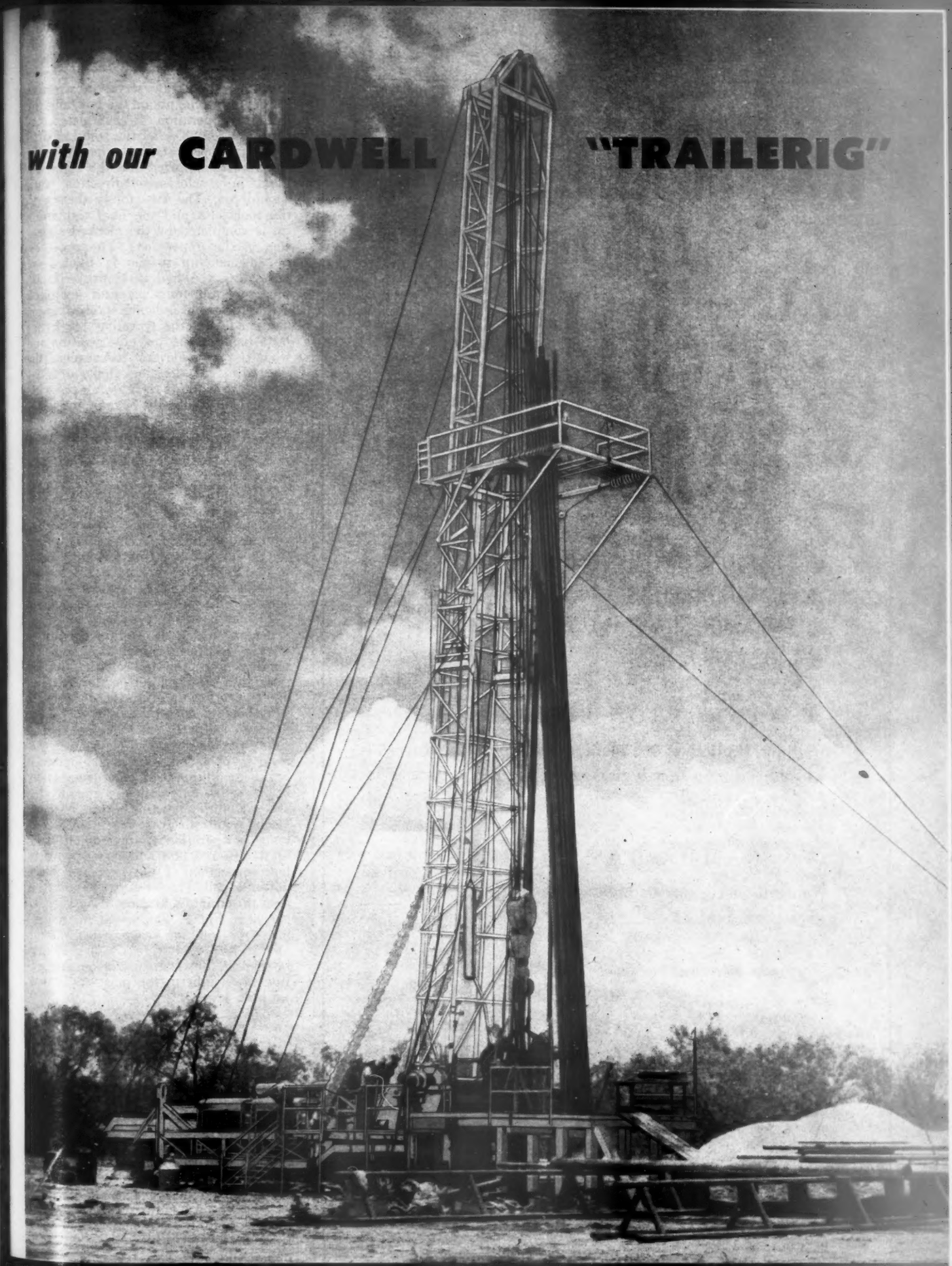

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the upper tong jaw serves as a guide for centering the pin on the box, and the stabbing operation is completed, as shown in Fig. 9. After the stand of drill pipe has been stabbed the spinning rollers are energized and the stand rotated in a clockwise direction until shouldered. The two tongs then grip the tool joint and the final tightening up is completed by the clockwise rotation of the upper tong. The predetermined make-up torque is limited by regulating the hydraulic pressure applied to the tong actuator cylinder. While the stand is being stabbed, spun, and made up, the traveling block has been rising in the deflected position and when the main elevator has reached the desired height, the block deflector is released. This allows the elevator to swing in and automatically engage the pipe.

Auxiliary Equipment

Personnel Elevator and Casing Stabbing Board.

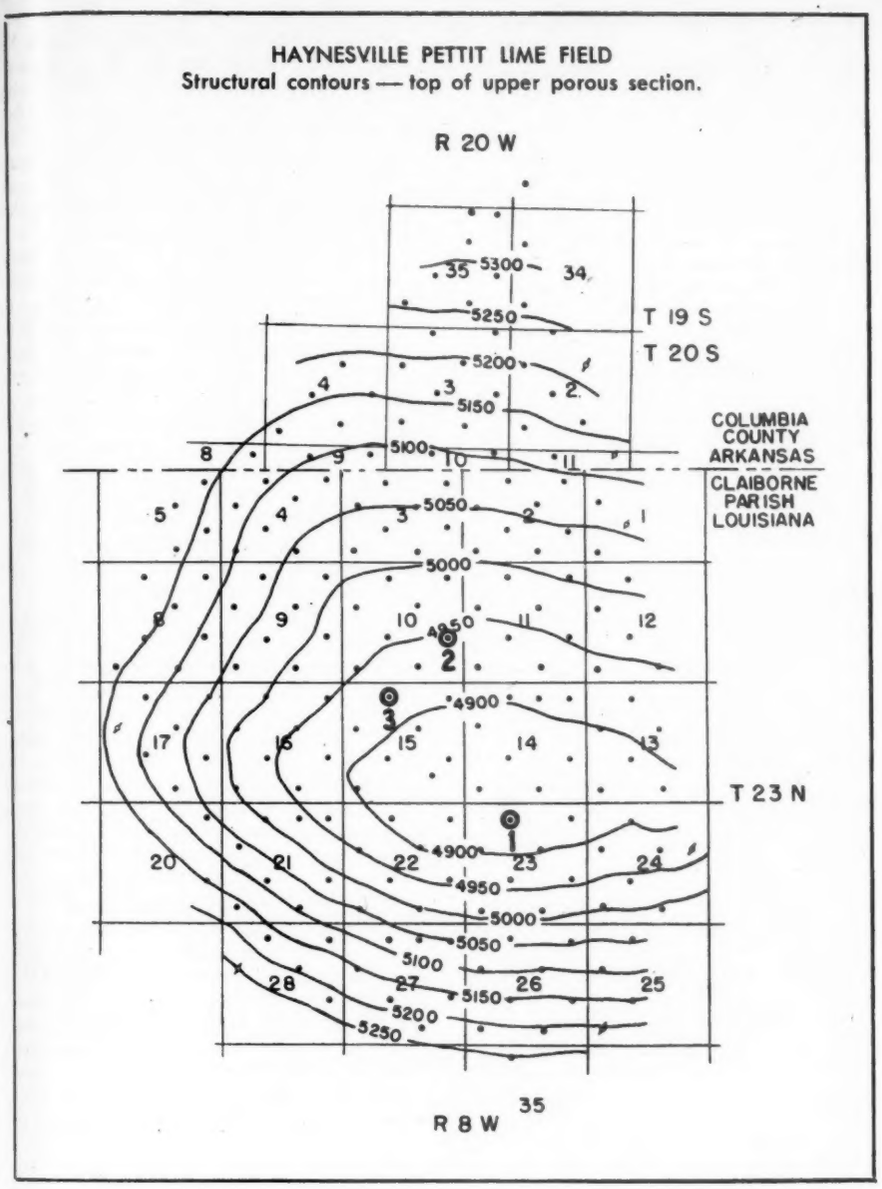
After installing the traveling block deflector rail in the derrick, it was concluded that it would accommodate equipment which would provide means for raising and lowering the derrickman to and from his working position. The elevator mechanism, shown in Fig. 12. consists of a trolley, similar in general to the carriage employed with the block deflector, which is equipped with a working platform. Small wire lines, extending from the top of the derrick through a control lever on the platform and down to the throttle on the air winch mounted on the lower end of the deflector rail, are controlled by the man riding the elevator. The elevator mechanism is provided with a foot-operated brake in addition to an emergency safety brake which automatically engages the rail when the hoisting cable becomes slack. While the traveling block deflector is in operation, the personnel elevator is lowered into and fastened to the bottom section of the traveling block deflector rail. This section of the rail is then raised into a horizontal position, as shown in Fig. 2. The use of this equipment in running casing of varying lengths has resulted in a saving of time in that the derrickman can quickly adjust his height to the most convenient working level.

Conclusion

Research work was initiated on the development of equipment for handling drill pipe in the derrick to cope with the special problems encountered when drilling at greater depths, to reduce the amount of physical effort on the part of crews, eliminate hazards, and to increase speed when making round trips. The purpose of this paper is to acquaint the drilling industry with the progress that has been made in the development of this type of equipment and to show some of the features now in full-scale operation.

Reference

1. AIME paper entitled "Semi-automatic Power-Operated Drilling Machinery," by Martin E. True and Bert L. Stone. ★ ★



Plastic Squeeze

This technique for shutting off unwanted fluids is good for doctoring old wells and new ones

J. D. BENEFIELD and J. C. McCORMICK*

THE plastic squeeze technique has been found to be extremely valuable in shutting off unwanted fluids in oil or gas wells. It is applicable, not only to original completions, but also for remedial work on older wells. Even in cases of limestone formations which have been previously acidized, plastics have been successfully used in hundreds of wells for temporarily or permanently sealing off a section. Such sections may later be reperforated and produced without harm to the producing formation.

Successful plastic jobs have been made in wells in such widely separated oil and gas producing limestone fields as the Illinois Basin, Kansas, Canada, West Texas, East Texas (Carthage), South Arkansas, and North Louisiana. Successful prolongation of the commercially productive life of many of these wells may be attributed to the proper placement of plastic.

Three typical examples of this type of treatment are described in this paper. The wells are in the Haynesville, Louisiana, Pettit lime field. This area is characterized by multiple pay zones exposed by the drilled wells and the fact that all wells have been heavily acidized upon completion. The purpose of the plastic squeeze application was to prepare the wells for selective production or selective injection. Some of the application techniques described are newly developed but are applicable to similar wells elsewhere.

This series of treatments demonstrated that it was possible to obtain a positive fluid seal in any desired section, to prevent production or injection into the blocked-off section. When necessary to reopen, merely reperforation is required, in some cases followed by reacidizing.

In order to present a clear picture, a brief summary of the characteristics of the reservoir, the formation, and other conditions follow.

The Haynesville field is situated in T-23N, R-8W, Claiborne Parish, Louisiana; and in T-19 and 20-S, R-20-W, Columbia County, Arkansas. The reservoir underlies a surface area of approximately 14,500 acres. The field was unitized in 1944 and is operated by the Haynesville Operators' Committee. There are approximately 190 wells in the unitized area.

The producing formation of the unitized properties is the Pettit lime. The reservoir is an example of a combination of a stratigraphic and structural trap, the permeability of the lime disappearing on the eastern end of the structure and the lime feathering to zero and shaling out on the other boundaries. A structural contour map on the top of the Upper Pettit is shown in Fig. 1.

The Pettit zone is found from approximately 5100 ft to 5600 ft and is divided into an upper and lower member, separated by approximately 40 ft of shale. The Upper Pettit is separated into A and B sections by a shale break, which is present in over 60 per cent of the field.

Completion practice in this field has been to set casing through and then perforate opposite the productive zones. All wells are acidized on completion.

Oil production is from three distinct zones; the A and B sections of the Upper Pettit zone, and the lower Pettit zone.

Gas injection for pressure maintenance began in 1945 in four of the structurally highest wells in the field. Currently, all gas injection is into the A zone.

Water injection for secondary recovery began in 1946. It was determined that it would be necessary to flood selectively the individual sections if maximum efficiency was to be achieved. This requires sealing off the other sections in the well for either injection or production. It also entails the use of a sealing medium which can be reopened later.

*Dowell Incorporated

EXCLUSIVE

The Authors

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J. D. Benefield came to Dowell from the U. S. Marine Corps, prior to which time he had attended Louisiana Polytechnic Institute and Colorado College. He has been directly connected with the field application of Dowell's Plastics services in the Gulf Coast — East Texas area since 1947. Recently he was promoted to sales engineer, for the area, covered by Dowell's Bossier City, Louisiana, station.

J. C. McCormick, a mining engineer from the University of Idaho, joined Dowell at Shreveport, Louisiana, in 1937. Prior to this time he had been associated with others, in both exploration and production, in the Mid-Continent and Illinois Basin areas. In 1949 he was transferred to Dowell's general office in Tulsa, where he has been concerned with development of the company's plastics and electric pilot services. Recently he was appointed manager of Dowell's personnel training program.

Most of the water at present is being injected into the B section. In order to simplify the operation it is desirable to keep the water flood front in the B section ahead of the A section. The two lenses of the Lower Pettit will be flooded after the water flood has been completed in the A and B sections of the Upper Pettit.

Special procedures are necessary during plastic plugging treatments, due to the fact that these wells have been previously acidized. Unless the enlarged channels and pores of the formation are blocked, an excessive amount of plastic is required to produce a shut-off. Extensive testing, both in the laboratory and in the Woodbine sand field of East Texas have shown that by using specified amounts of specially graded inert filler materials in the liquid plastic, its penetration into the sand can be controlled as desired. In plastic treating in the Haynesville field, therefore, the formation is first packed with sand, after which plastic is squeezed into this sand-packed section. This can be accomplished in about the same time as a regular acidizing treatment and with no more difficulty than that attending any service job.

Essentially, all treatments are made in the following manner. The well is first killed with low surface tension water after which a radiation log survey is run. A wire line check is next run using feelers to locate the datum collar and correlate it with the radioactive log. Tubing is next run into the well, with a retainer in the tubing string and predetermined length of tail-pipe below it. Immediately above the retainer is the four-plug landing device used in controlling the plastic.

The tubing is run to the bottom and measurements checked with wire line. The tubing is then picked up a definite distance off bottom and the retainer set. Water is next pumped down the tubing from the surface. A special sand-jetting device injects as much as one sack of sand per minute into the fluid stream. This sand is carried to the bottom of the well, on vacuum, until the packing becomes effective. Additional sand is injected in order to pack the sand more tightly. Care is taken not to approach the pressure necessary to fracture the formation or lift the overburden.

When it is believed all possible sand has been forced through the perforations and into the formation, pumping is stopped, the retainer is unset, and bottom is tagged with the tubing to locate the top of the sand. Usually there is too much sand in the well. This excess is reverse-circulated from the well until the top of the sand is at the point desired. This leaves sand in the casing protecting any lower perforations, and a sand-packed section behind the casing. Regular squeeze technique, using filler plastic, is then employed to seal off the exposed sand-packed section.

After the plastic has been squeezed the well is shut-in for 24 hr. Then the tubing is pulled and the retainer and other squeezing equipment removed. A rotary bit is placed on the tubing string and the plastic drilled out of the casing to a point previously set for testing. In the case of segregation of the A section from the B section, this is usually halfway into the shale break. The well is then pressure tested to 1800 or 2000 psi. In all but a few isolated instances, the plastic squeeze jobs have been effective on the first application. Cement squeezing has not proved effective unless it is possible to have some cement left in the casing above the top of the perforations.

For a more complete understanding of the exact treating procedure employed in the Haynesville field, a more detailed description of three specific case histories follows. The location of these wells is shown in Fig. 1. For refer-

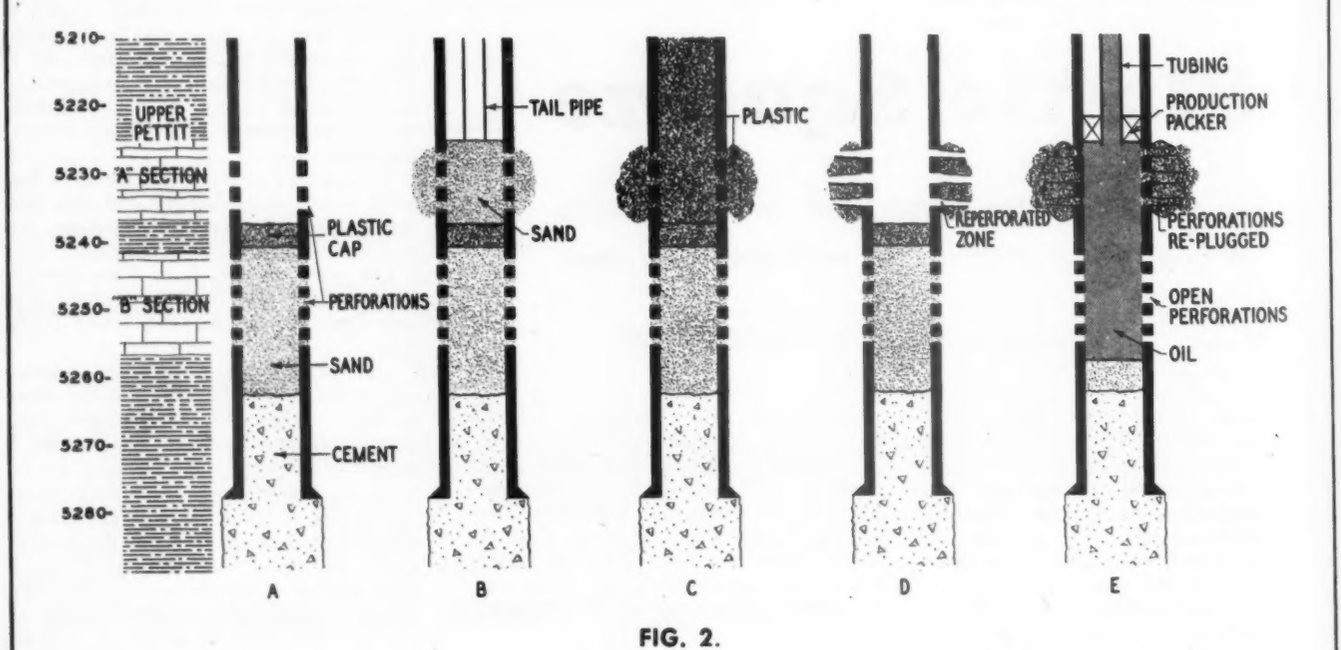

FIG. 2.

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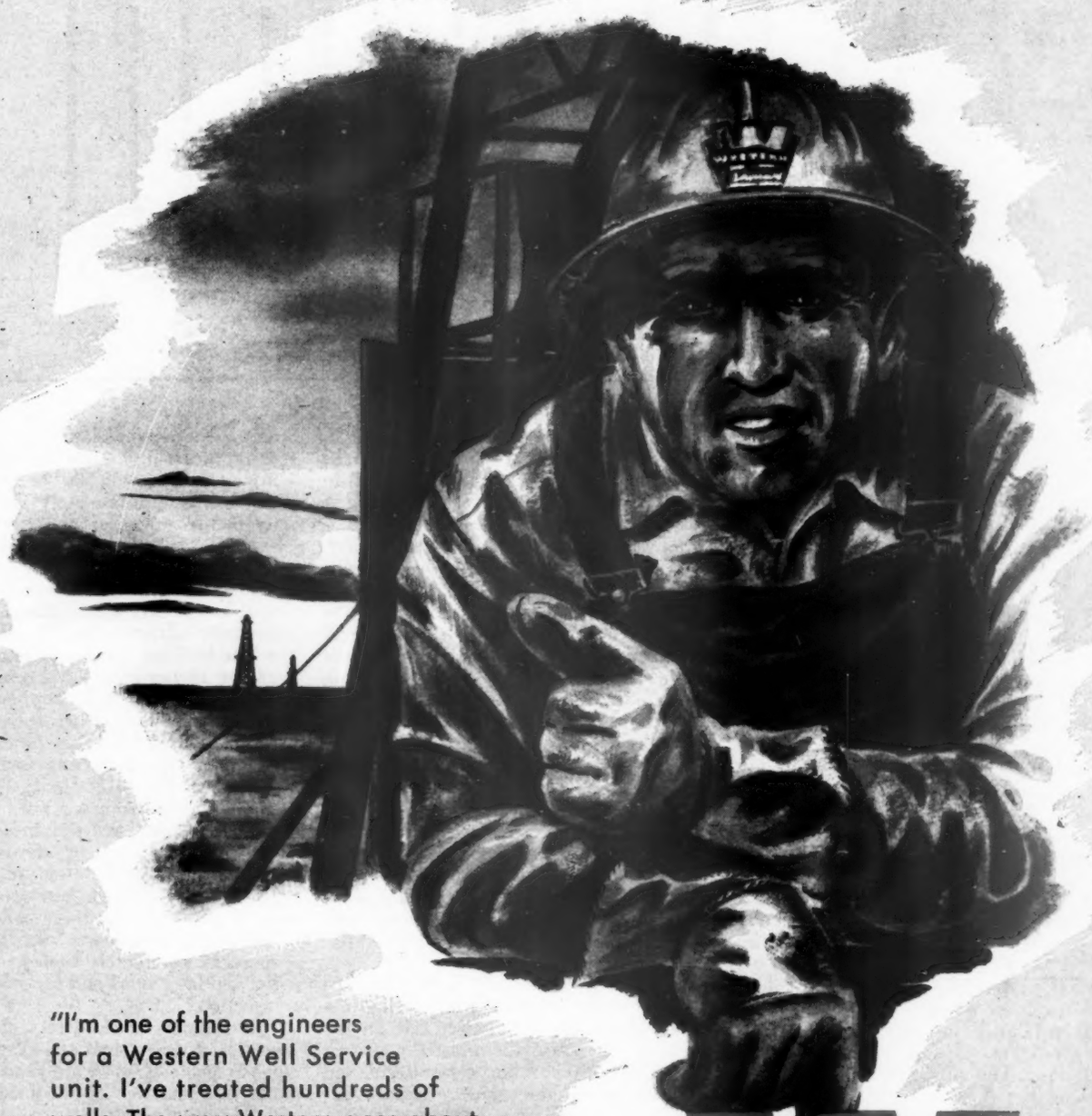

"I'm one of the engineers for a Western Well Service unit. I've treated hundreds of wells. The way Western goes about treating wells from an engineering standpoint, and the modern specially designed equipment Western uses for each job certainly has sold me on Western. If you'll take the trouble to check, you, too, will find that Western does an outstanding job!"

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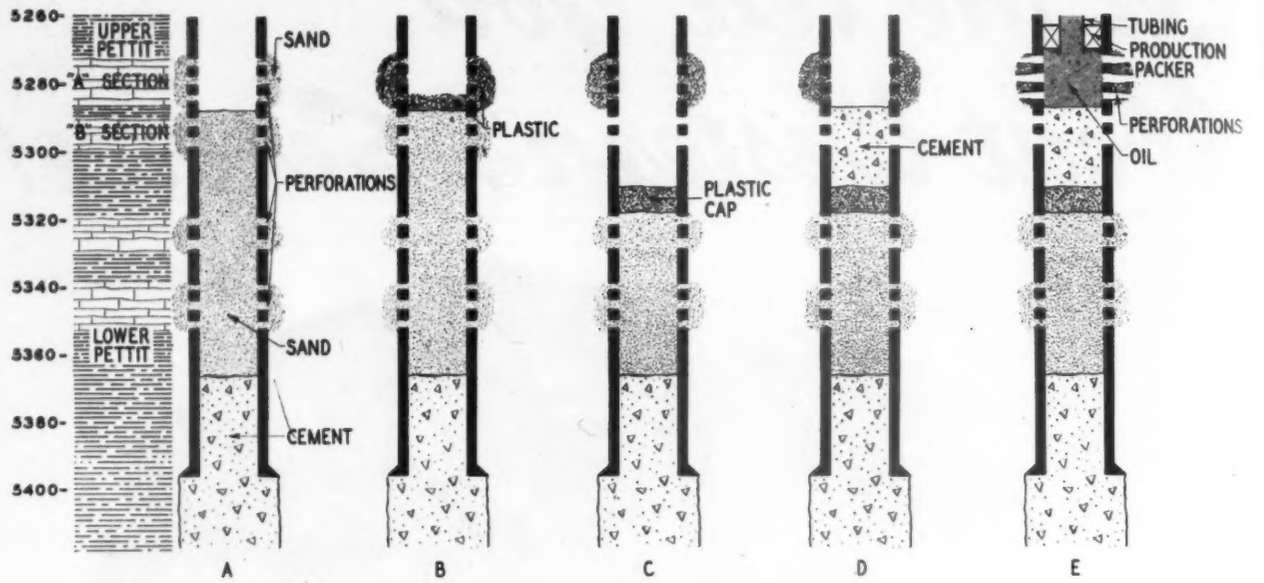

FIG. 3.

ence purposes, these wells are designated as No. 1, No. 2, and No. 3.

Well No. 1 is HOC 23-3. It was completed in April, 1942, with perforations only in the Upper Pettit zone, the Lower Pettit not being present at this location. It was acidized on completion with 5000 gal.

This well had been worked over previously (1945), the purpose of the remedial work at that time being to seal off the B section so that gas could be injected into the A section. An Electric Pilot Permeability Survey indicated maximum loss of fluid into the lower 4 ft of the B section. Sand was used to fill the well to the shale break between the A and B sections, and a plastic cap placed thereon, using the bailer method. Following this workover, gas was injected into the A section at an average rate of 642,000 cu ft per day. Gas injection was discontinued in January, 1949, until May, 1951, when it was tested for 6 days. At this time gas injection averaged 1,400,000 cu ft per day.

A workover was recommended on this well primarily to analyze the merits of sand-packing and plastic squeeze technique. The objectives were: (1) To seal off the A section, drill the plastic out of the casing down to the shale break and pressure test to see if the squeeze job was successful. (2) To reperforate the A section and determine if original production potential could be restored from the sealed-off section, acidizing to be used if desirable. (3) To sand-pack and squeeze off the A section a second time, drill out the plastic from the pipe and uncover the B section, producing the well from the latter zone.

The well was presented for this remedial work in May, 1951, with the temporary plug covering the B section, and perforations as shown in Fig. 2-A. The well was killed, using low surface tension water. Tubing (2½-in.) was run and the retrievable retainer set 186 ft from bottom; end of tail-pipe for sand-packing at 5201 ft. Twenty-four sacks of sand were lubricated into the well in four batches, the first batch being 7 sacks; the second, 7 sacks; the third, 5 sacks; and the fourth, 5 sacks. Thirty-six barrels of water were used to displace each batch (tubing capacity 30 bbl). The surface pressure, when the last batch of 5 sacks had been displaced, reached 3000 psi and held, which was believed satisfactory for the squeeze job to follow. This pressure was then released, the retainer unset and bottom was tagged with the tubing. The top of the sand was found to be at 5225 ft, as shown by Fig. 2-B.

The sand in the casing from 5226 ft to 5237 ft was reverse circulated from the well. An injection test pumping water into the formation at 1.5 bbl per minute required 2000 psi surface pressure, indicating the A section to be sand-packed and ready for plastic application.

One hundred and fifty gallons of plastic were next displaced through the tubing, which was then raised 246 ft, the retainer set, and the plastic squeezed away. After approximately 60 gal had been squeezed, the surface pressure was 4900 psi, which was deemed sufficient. The well was then shut in for 24 hr for the plastic to set (Fig. 2-C) after which the plastic remaining in the casing was drilled out to 5237 ft and the well pressured to 2000 psi. The squeeze held without leakage.

After this, the formation was jet-perforated from 5225 ft to 5235 ft. (Fig. 2-D). The well would not flow so it was placed on gas-lift and produced 25 bbl per day. A selective acidizing job was attempted but it was impossible to kill the well with water. The gas-lift was then hooked up so that gas could be blown around the bottom of the tubing, and the well was cleaned in this manner. The shut-in pressure rose to 1100 psi so the acidizing job was postponed to try a gas injection test. The rate of injection was 430,000 cu ft per day which was approximately 1/3 its capacity before workover and ½ its normal capacity. It is believed this was due to the well's not being completely cleaned before the gas injection test began, as well as the fact that the formation was partially water-blocked.

The well was then acidized with 1000 gal of 15 per cent low surface tension acid and 4000 gal of 7½ per cent low surface tension acid. Pressure following acidizing was 1900 psi. Two days after treatment the well was producing an estimated 48 bbl of fluid, 97 per cent water. Gas injection was then begun and 48 hr later the gas being injected at the rate of 762,000 cu ft per day at 1650 psi. When the pressure was increased to 1800 psi the injection rate was 1,200,000 cu ft per day. This was considered as satisfactory evidence that a section could be completely sealed off by plastic, and later reopened for production or injection.

It was now desired to seal off the A section. Using a total of 44 sacks of sand the A perforations were sand-packed in the same manner as previously and 150 gal of filler plastic were spotted in the casing over the perforated zone. Approximately 115 gal were squeezed into the formation before a maximum pressure of 5100 psi was reached.

After the plastic was set, the plastic remaining in the casing was drilled out to 5236 ft. The squeeze job on the A section was then pressured to 2200 psi and held without leakage. The plastic and sand protecting the B section were next drilled and washed out to 5257 ft, leaving the well at the end of the remedial work as shown in Fig. 2-E. The well cleaned itself when allowed to flow but was shut-in as soon as it was clean on account of a high oil/gas ratio.

Well No. 2 is HOC 10-9. This well was

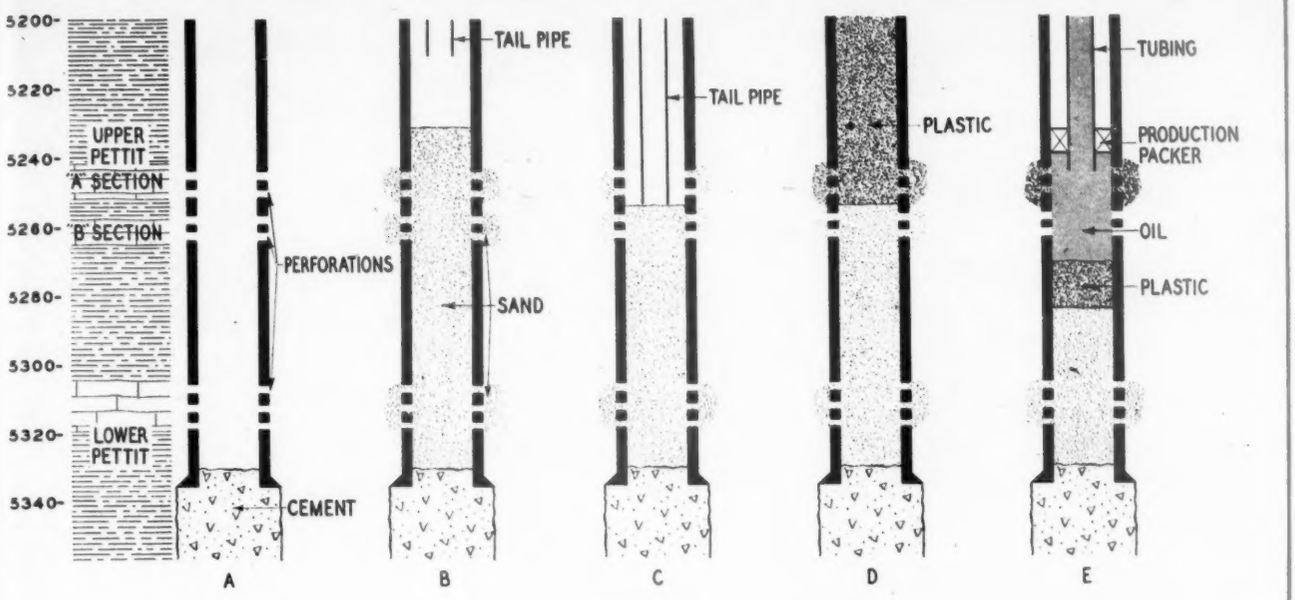

FIG. 4.

completed May, 1942, and had been acidized with 5000 gal. This well had been previously sand-packed by HOC, the top of the sand being 5285.5 ft. The 2½-in. tubing was bottomed at 5247 ft and the retainer set at 5062 ft (185 ft up hole). The sand packing of the A section was accomplished in the same manner as described in Well No. 1. A total of 42 sacks of sand was lubricated into the well and pumped away until a surface pressure of 3500 psi was reached and maintained. Then the excess sand was reverse circulated from the hole, the top of the sand at the beginning of the plastic squeeze being 5285.5 ft, as shown in Fig. 3-A. This sand-packing of the A section was such that it required 2300 psi to pump water into the formation. Using 100 gal of filler plastic, 60 gal were forced into the formation with a final pressure of 3100 psi. It would appear that additional plastic should have been used, since the final squeeze pressure attained was not as high as is usual. This was further borne out by the fact that only 5 ft of plastic remained in the casing. (Fig. 3-B). This was drilled out to 5285 ft and the well was pressure tested to 2200 psi. This pressure dropped to 1500 psi in 15 min indicating there was a slight loss to the formation, but it was not considered sufficient to require squeezing again. This gave additional evidence that more plastic should have been used for the squeeze job.

The remainder of the plastic was then drilled out and the sand washed out to 5317 ft. Ten feet of plastic were placed on top of the sand using the bailer method, the top of the plastic at this stage being 5307 ft, as shown in Fig. 3-C. The remedial work thus far was for the purpose of selectively producing from the B section. Upon testing it produced 320 bbl of fluid per day, most of which was water.

The B section was then cement squeezed, the top of the cement following this operation being left at 5284 ft. It should be noted here that cement squeeze technique is successful in cases where cement is left in the pipe above the squeeze perforations, but it is not usually successful when drilled out. The condition of the well at this stage is shown by Fig. 3-D. The A section was then jet-perforated and acidized. (Fig. 3-E). This well is currently producing 80 bbl of oil per day on gas-lift.

Fig. 4-A shows well No. 3 (HOC15-3) as it was presented for sand-packing and plastic remedial work. The first objective was to sand pack all perforated zones. Open ended 2½-in. tubing was run to 5211 ft, the retainer (on tubing at 4865 ft, with the 4-plug landing tool above) set, and the annulus filled with water.

The sand packing was accomplished by lubricating 35 sacks of sand into the tubing. The sand was injected in four batches, each batch being displaced with 40 bbl of low surface tension water. The first batch consisted of 16 sacks of sand; the second of 7 sacks; the third of 6 sacks; and the fourth of 6 sacks. During the last batch, the surface pressure rose to 3400 psi after 33.5 bbl of water had been displaced into the tubing. The pressure was then bled off, the tool released and the top of the sand found to be at 5226 ft (Fig. 4-B). Calculations indicated that approximately 120 gal of sand had been packed into all the perforated zones, leaving 85 gal of sand in the casing.

The next step was to reverse circulate the excess sand from the well, leaving the top of the sand at 5255 ft, the shale break between the A and B sections (See Fig. 4-C). With the well in this condition it required 1500 psi to pump low surface tension water into the formation at an injection rate of 1.5 bbl per minute.

One hundred and twenty gallons of filler plastic were then displaced through the tubing. The tubing was raised 195 ft and displacement of plastic into the formation begun as shown in Fig. 4-D. After approximately 30 gal of plastic had been injected into the formation, the surface pressure reached 4900 psi and held. This entire operation, from first setting the retainer and filling the annulus with water to the final squeeze on the plastic, consumed 7 hr 15 min.

The well was then shut in for 24 hr, after which the tubing was pulled, retainer was drilled out of casing down to 5252 ft. The squeeze job on the A section was pressure tested to 1800 psi and held fast without leakage. Thereafter, the remaining plastic was drilled out, and the sand washed out to approximately half way between the B section and the Lower Pettit. Twenty gallons of filler plastic were then dumped on top of the sand and the well was rigged for gas-lift production from the B section as shown in Fig. 4-E. It is currently producing 70 bbl of oil per day. It should be noted that reperforation of the B section and reacidization was not necessary in this well for this section had been protected throughout against plastic entry by the sand-packing technique.

Acknowledgment

The writers wish to express appreciation to the Haynesville Operators Committee for their cooperation. Liberal use was made of reports and maps furnished by its engineering staff.

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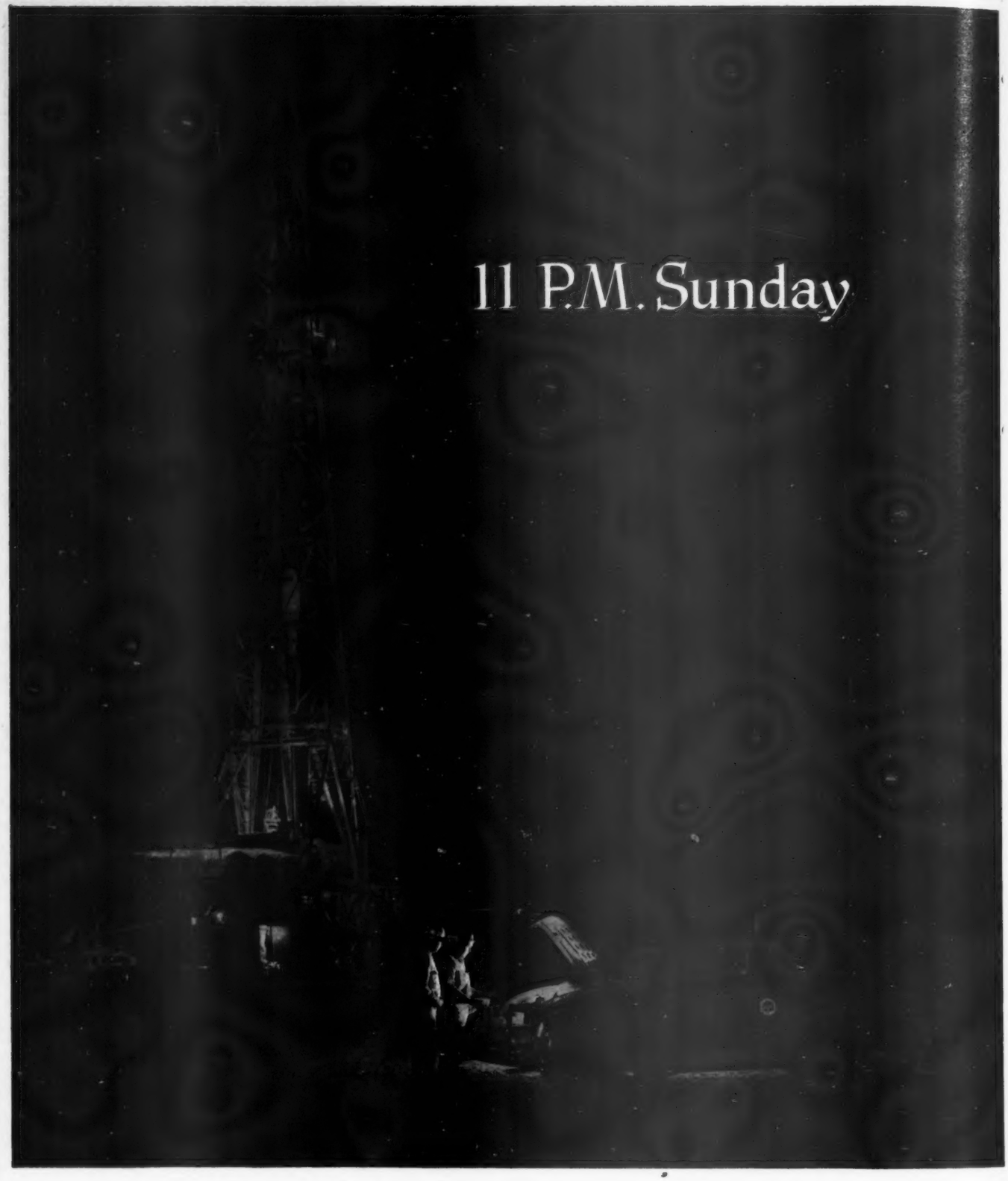

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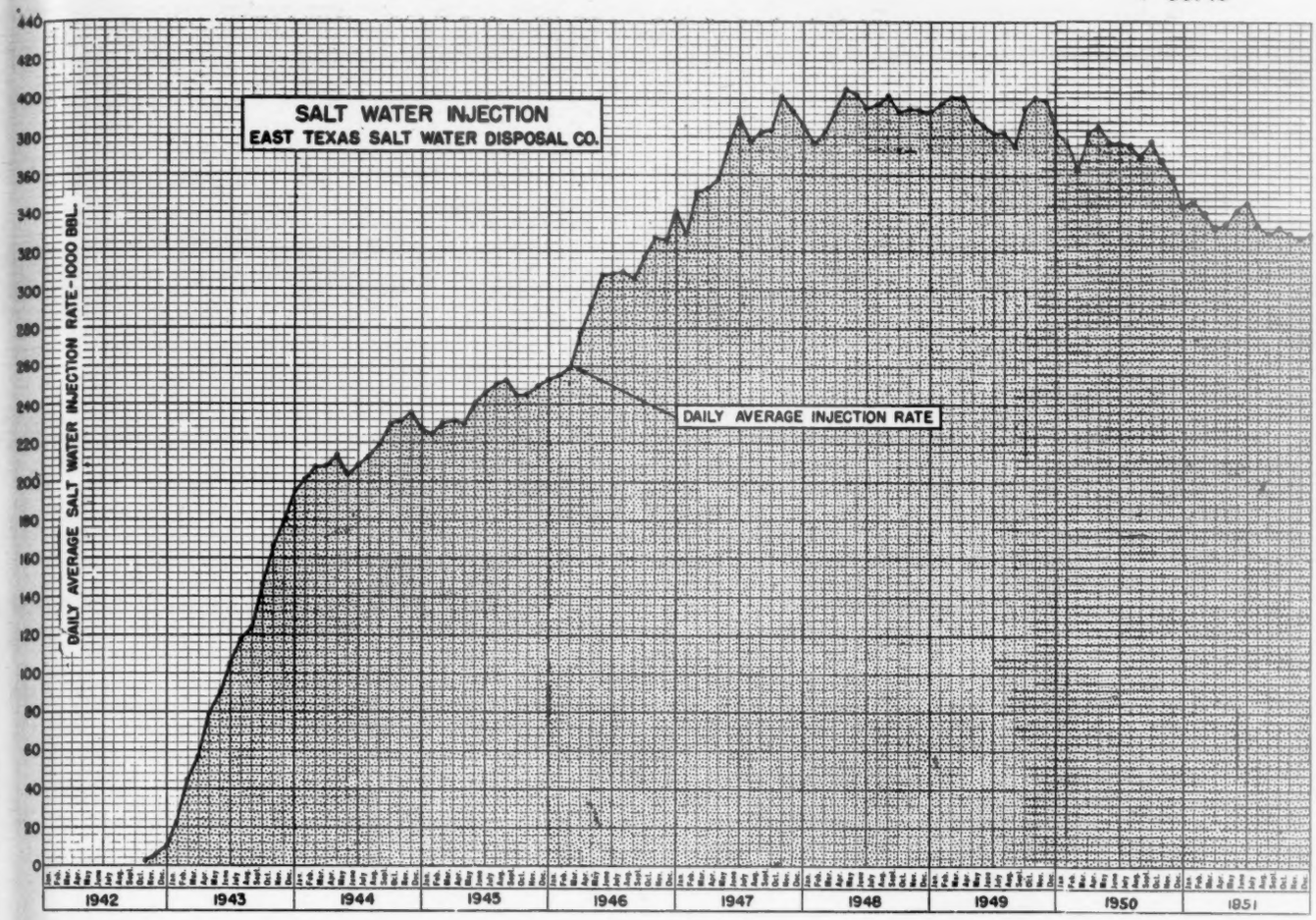


A Look at

Salt Water Disposal in East Texas

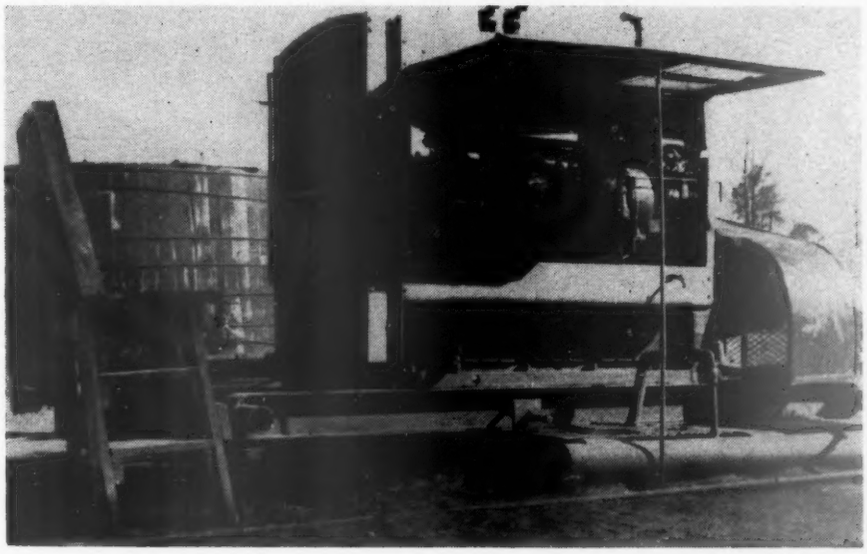
Accomplishments of the Past and Probabilities of the Future

W. S. MORRIS

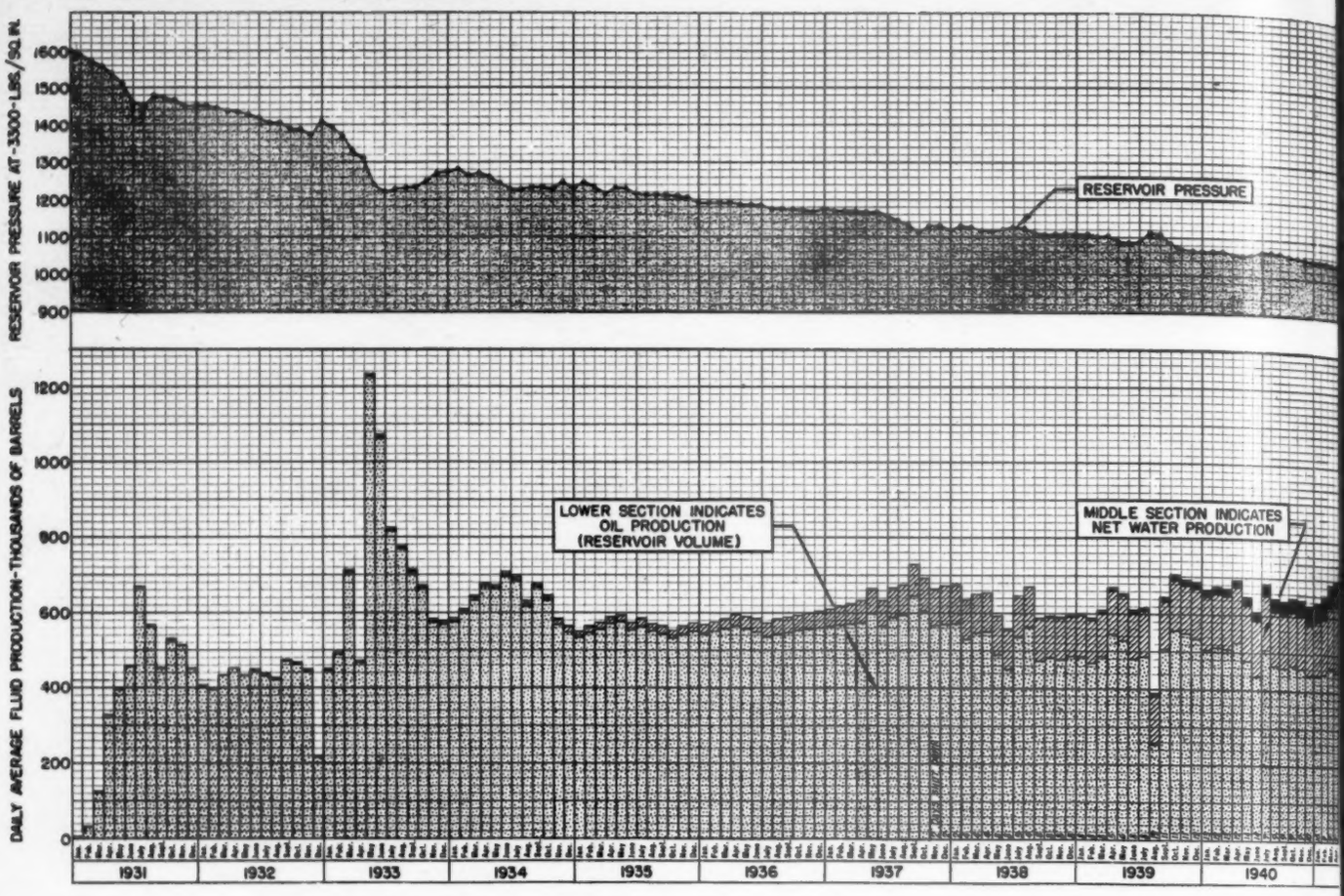
EXCLUSIVE

THE return of salt water to the Woodbine sand in the East Texas field dates back to the experimental project of 1936, followed by a full scale operation that began in June 1938.[1] The field-wide plan for salt water disposal was begun in 1942, when 250 large and small operators in the field joined together to form the East Texas Salt Water Disposal Company to operate in the nature

[1] "Subsurface Disposal of Salt Water in the East Texas Field," by W. S. Morris, *The Petroleum Engineer*, July 1948.



A Buda engine used to drive the injection pump at the Payne No. 2 salt water injection well.



This graph of the performance record of East Texas field reveals at a glance the amounts of oil and water

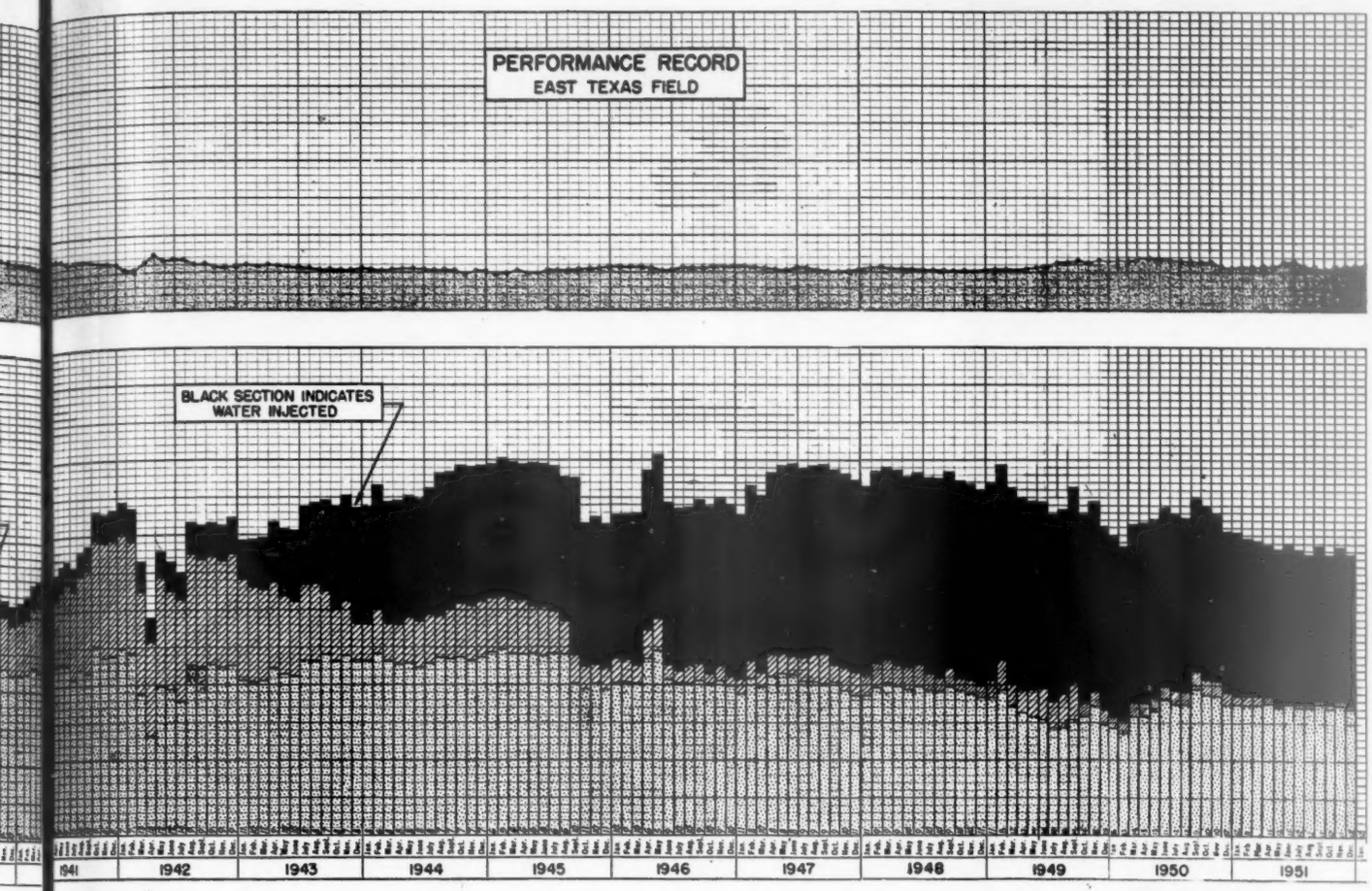
of a public utility in taking salt water produced from the various leases in the East Texas field and returning it to the Woodbine reservoir below the oil producing section of the sand.

In 1942 when the Salt Water Company was organized, the salt water production from the East Texas field was in excess of 400,000 bbl a day. The oil companies in the field were operating under a district court injunction that restrained them from releasing any salt water into surface streams serving the area. The towns of Beaumont and Port Arthur had complained of the pollution by salt water of the Angelina and Neches Rivers watersheds, to the extent that the State Board of Water Engineers, the Health Department, the Fish, Game and Oyster Commission, and others, found it necessary to seek injunctive relief against further pollution by salt water.

Disposal Problem Forces Action

The Salt Water Company, organized in 1942, was born of necessity for there was no other way to cope satisfactorily with the fieldwide salt water disposal problem other than through a cooperative effort. At the time the Salt Water Company was organized, two purposes were advocated: First, the elimination of the pollution and contamination of the surface streams by salt water; and second, the hope that the return of the salt water to the Woodbine reservoir would maintain the reservoir pressure above the point at which gas came out of solution of the oil. The primary purpose of the company at the time of its organization was to properly dispose of the salt water produced as a necessary

A Waukesha engine driving an injection pump at the Payne No. 1 salt water injection well located west of Kilgore. The plant operator (Roe Williams) is checking the operating condition of the engine.



produced, the volume of water injected and the reservoir pressure, which has been maintained by the water injection.

The Author

Winfield S. "Buck" Morris is vice president and general manager of the East Texas Salt Water Disposal Company, Kilgore, Texas. A graduate of North Carolina State College of Agriculture and Engineering, Morris spent two years as a junior engineer for the Empire Gas and Fuel Company, and three years a petroleum engineer for Bureau of Mines. From 1929 to 1936 he was petroleum engineer for Indian Territory Illuminating Oil Company, and in 1936 he was admitted to the Oklahoma Bar. He helped organize the East Texas Salt Water Disposal Company and has served as its vice president and general manager since 1942.

adjunct with the oil from the Woodbine sand.

Salt water disposal facilities were rushed to completion and by March of 1943, an average of 50,000 bbl a day was being injected by the Salt Water Company. This figure rose to 100,000 bbl a day injection by June of the same year and reached 200,000 bbl a day by January of 1944. In May of 1946 the injection volume had reached 300,000 bbl a day and in October 1947, over 400,000 bbl a day was being injected. The rapid increase in salt water disposal facilities made it possible to return an ever increasing percentage of the salt water that was actually produced.

It was realized that salt water disposal facilities were expensive—costing in the neighborhood of $10 to provide lines, plants, and wells to inject one barrel of water (to provide salt water disposal facilities to handle 10,000 bbl of water a day in a particular area, would require the expenditure of approximately $100,000.)

Means of controlling the volume of salt water produced were studied with the result that after a full hearing before the Railroad Commission of Texas, an order was promulgated to permit the shutting down of wells producing in excess of 100 bbl of water a day. The oil allowable (determined from a decline curve) would be transferred to other wells in the field that did not produce

Salt water produced and injected — East Texas Field.

Month	Salt water produced		Salt water injected		Per cent injected	Producing days	Shut down days
	Total bbl	Daily average bbl	Total bbl	Daily average bbl	%		
1942	129,080,465	353,645	29,399,277	80,546	22.78	237	128
1943	145,503,540	398,640	73,642,841	201,761	50.61	258	107
1944	170,423,237	465,637	124,136,102	339,169	72.84	276	90
1945	176,152,000	482,608	137,179,479	375,834	77.99	276	89
1946	174,661,000	479,624	156,009,065	427,422	89.12	258	107
1947	198,729,000	544,463	180,437,673	494,350	90.80	255	110
1948	207,467,000	566,850	190,810,209	521,339	91.97	249	117
1949	199,446,000	546,427	184,616,830	505,800	92.56	206	159
1950	183,111,000	501,673	170,263,050	466,474	92.98	218	147
1951	153,459,000	420,436	149 762 005	410,307	97.59	226	139
1952							
January	12,896,000	416,000	12,649,241	408,040	98.09	19	12
February	12,006,000	414,000	11,808,741	407,198	98.36	18	11
March	12,927,000	417,000	12,543,989	404,645	97.04	19	12
April	12,600,000	420,000	12,367,216	412,241	98.15	19	11
May	12,989,000	419,000	12,719,007	410,291	97.92	19	12
June	12,150,000	405,000	12,001,884	400,063	98.78	19	11
July	12,710,000	410,000	12,470,708	402,281	98.12	19	12
Total	88,278,000	414,451	86,560,786	406,389	98.05	132	81

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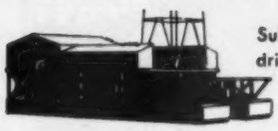
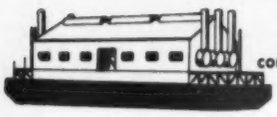


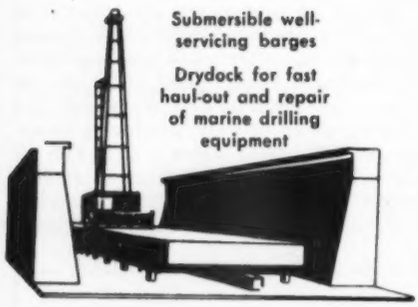
Submersible drilling barges

Tugs



Boiler and compressor barges

Water, oil, and supply barges



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An electrically driven centrifugal pump delivering water from the settling basin to the filters at the Payne treating plant west of Kilgore. Note the salt water pipe line is non-metallic.

Comparison of well status reports — salt water produced.*

Number of wells	Jan. 1, 1950	July 1, 1950	Jan. 1, 1951	July 1, 1951	Jan. 1, 1952
Flowing wells making water	452	450	485	488	470
Pumping wells making water	4802	4621	4492	4389	4403
Pumping wells not making water	4673	4739	4729	4751	4701
Total pumping wells in field	9475	9360	9221	9140	9104
Gas lift wells making water	5	17	13	21	18
Gas lift wells not making water	303	300	303	314	301
Total gas lift wells in field	308	317	316	335	319
Wells Producing Salt Water					
Marginal wells	1479	1270	1045	1004	1058
Proratable wells	3780	3818	3945	3894	3833
Total wells making water	5259	5088	4990	4898	4891
Daily Salt Water Production					
Marginal wells	391,201	324,191	251,367	228,491	234,078
Proratable wells	251,482	275,096	291,904	280,464	258,994
All water wells	642,683	599,287	543,271	508,955	493,072
Average Daily Salt Water					
Marginal well	264.50	255.27	240.54	227.58	221.25
Proratable well	66.53	72.05	73.99	72.02	67.57
All salt water wells	122.21	117.78	108.87	103.91	100.81
Other Data					
Water wells shut down with allowables transferred	578	583	665	706	740
Key wells with allowable transferred	68	75	72	82	82

* Railroad Commission data.

Water wells shut down and allowables transferred to other leases.

Month Year	No. wells shut down	Daily oil allowable bbl	Daily water production bbl	Total allowable to be transferred bbl
July 1947	Order No. 6-10,956 issued by Railroad Commission			
Total 1947	100	911.43	33,841.58	301,388
Total 1948	371	3,304.53	129,183.62	1,123,667
Total 1949	287	2,944.47	96,406.90	1,071,192
Total 1950	371	3,577.53	128,219.42	1,294,676
Total 1951	408	3,927.37	135,192.13	1,423,805
1952				
January	11	127.94	2,927.49	46,365
February	38	412.26	12,255.09	165,845
March	18	216.79	5,125.26	84,840
April	18	155.43	6,101.03	56,797
May	22	232.89	6,819.54	86,735
June	31	323.33	10,005.63	122,448
July	23	220.79	8,142.89	80,694
Total 1952	161	1,689.43	51,376.93	643,724
Grand total	1698	16,354.76	574,220.58	5,858,452
Average	Well	9.63	338.17	3,450

any water. This order was issued by the Railroad Commission in July 1947, and during the rest of the year (1947) a total of 100 wells were shut down and their allowable transferred; these 100 wells produced 33,842 bbl of water a day at the time they were shut down. The advantages of shutting water wells down became better known in 1948 when a total of 371 water wells that produced a total of 129,184 bbl of water a day, were shut down. Notwithstanding the elimination of these 471 large water wells, the volume of water produced continued to increase until a maximum of 670,575 bbl a day was reported on a "producing day" basis on January 1, 1949.

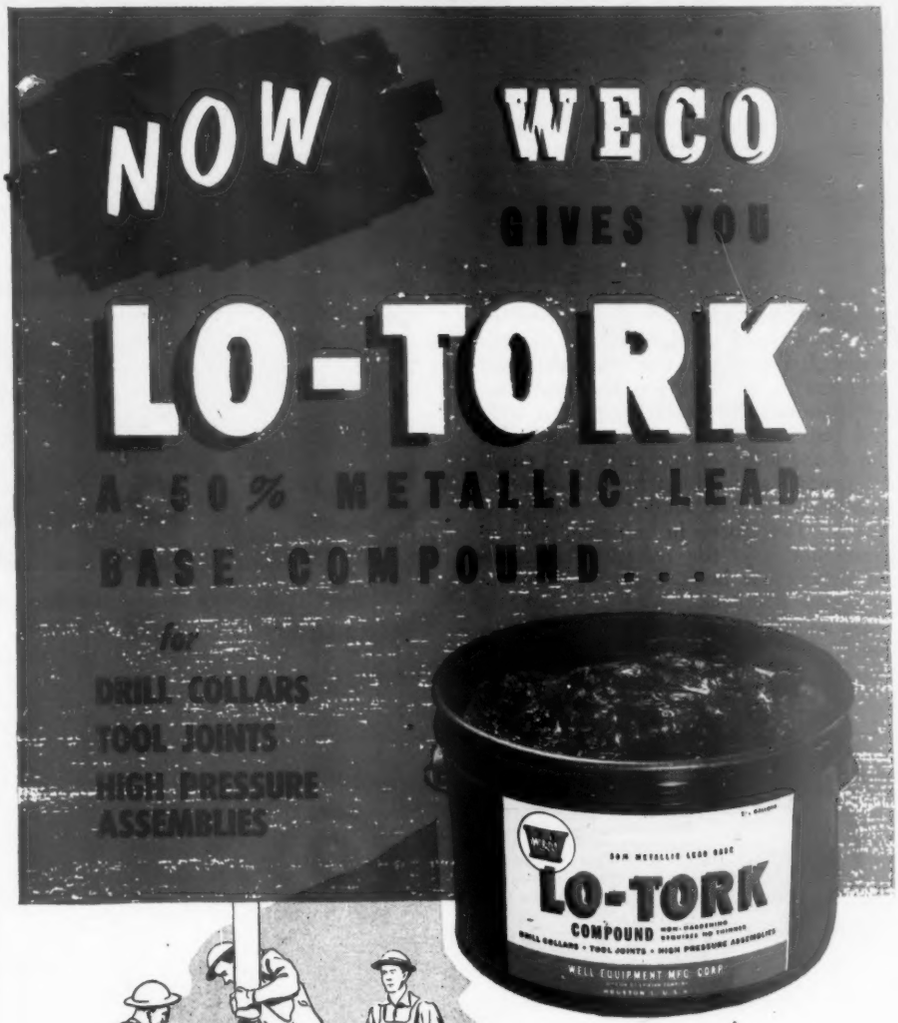
The idea of shutting in large water wells continued to spread with the result that in 1950, 371 additional wells were shut down that had produced 128,219 bbl of water a day. Similarly in 1951, 408 more water wells were shut down, which had produced 135,192 bbl of water a day. This very substantial reduction in salt water production during 1950 and 1951 substantially exceeded the rate at which new water wells became large water producers and more than counteracted the normal tendency for salt water production to increase with progressive depletion of the field.

Water Wells Shut In

Data indicate that had this rather sudden change in operating practices of salt water producing wells not occurred, the maximum salt water production from the field would have been expected about 1960. Thereafter abandonment of wells accompanying further depletion of the field should have been expected to cause a gradual reduction in salt water production. In view of the large number of salt water wells now shut down and the indications that additional large water wells will be shut down during the coming months, (161 large water wells that produced 51,377 bbl of water were shut in during the first 7 months in 1952.), it now appears that the maximum salt water production from the East Texas field was passed about the first of the year 1949, and that future salt water production will remain substantially below the 1948 maximum level.

Almost from the beginning of the operations of the East Texas Salt Water Disposal Company in 1942, the reservoir pressure was stabilized. The accompanying illustration (Fig. 4) shows how the bottom hole pressure has remained practically constant from October 1942 to the present time. In fact when the Salt Water Company started operations on October 1, 1942, the average bottom hole pressure was 1020.70 psi. On July 1, 1952—nine years and nine months later, the average bottom hole pressure was 1021.72 psi, an increase of 1.02 psi. During this interval, the East Texas field produced 1.117 billion barrels of oil and 1.718 billion barrels of salt water; a total of 1.449 billion barrels of salt water were returned to the reservoir of which the Salt Water Company injected 1.061 billion barrels.

If the oil operators continue to shut



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in their large water wells, as has been done over the past several years, it is believed that the Salt Water Company will be able to extend its lines to new water producing leases and continue to handle practically all the salt water produced in the field. It is estimated in excess of 98 per cent of all water produced in the field is now returned to the reservoir.

The fresh water streams running through the East Texas oil field and the drainage area of the field, are practically free from contamination of salt water. It is believed that the salt water problem in the area has been satisfactorily solved. The solution of this difficult problem was possible only through the cooperation of the large and small oil producers working in full cooperation with the Railroad Commission of Texas. Therefore, in addition to the maintenance of the reservoir pressure, an answer has been worked out to the pollution problem.

In addition to these benefits, it has been estimated by reliable authorities that as a direct result of the salt water disposal program more than 600,000,000 bbl of additional oil will be recovered from the field.[2]

A 7¼ by 10 Gardner Denver injection pump at the Payne No. 2 salt water injection well west of Kilgore. This pump is capable of delivering 15,000 bbl of water a day to the injection well.

Fluid withdrawals and reservoir pressure — East Texas Field.

Year month	Daily average production—barrels: Oil (tank)	Oil and gas (reservoir)	Salt water	Total fluid	Water injected B/D	Net fluid withdrawal B/D	Reservoir pressure psi
1943	352,243	455,877	398,640	844,517	201,761	642,756	— 3.27
1944	368,219	466,100	465,637	931,737	339,169	592,568	—11.20
1945	358,964	454,385	482,608	936,993	375,834	561,159	14.91
1946	330,340	418,152	479,624	897,776	427,422	470,354	0.05
1947	320,403	405,573	544,463	950,036	494,350	455,686	— 4.81
1948	305,683	386,941	566,850	953,791	521,339	432,452	— 3.00
1949	256,239	324,353	546,427	870,780	505,800	364,980	21.26
1950	268,052	339,306	501,673	840,979	466,474	374,505	—15.70
1951	272,812	345,332	420,436	765,768	410,307	355,461	7.00
1952							
January	266,993	337,966	416,000	753,966	408,040	345,926	1020.95(1-1-52)
February	269,804	341,524	414,000	755,524	407,198	348,326	1018.34
March	265,939	336,632	417,000	753,632	404,645	348,987	1023.58
April	273,264	345,904	420,000	765,904	412,241	353,663	1023.70
May	262,524	332,309	419,000	751,309	410,291	341,018	1018.32
June	272,459	344,885	405,000	749,885	400,063	349,822	1021.46
July	264,193	334,422	410,000	744,422	402,281	342,141	1021.72(7-1-52)
Total	57,045,163	.....	88,278,000	.....	86,560,786	.....	
Average	267,818	339,010	414,451	753,461	406,389	347,072	

Maintains Pressure

In addition to the benefits of increased recovery of oil and the elimination of salt water pollution from the area, the return of salt water to the reservoir has maintained the bottom hole pressure to the extent that the use of mechanical lifting of the oil has been considerably reduced. On January 1, 1942, the Railroad Commission reported 7132 pumping wells in the field. On January 1, 1949, this number had increased to 9197 wells, but by January 1, 1952, the number of pumping wells was reduced to 9104 wells. The number of wells making salt water has decreased from 5659 wells on January 1, 1942 to 4891 wells on January 1, 1952. The maintenance of bottom hole pressure has made it possible for many wells to continue to flow which otherwise would have required pumping equipment had the pressure sharply declined.

The program for returning salt water to the East Texas reservoir has made it possible to produce large quantities of crude petroleum from the field without serious damage to the reservoir and its future recovery possibilities.

[2](R. E. Hardwicke, "Conservation of Oil and Gas, a Legal History—1948" pp. 474-478 American Bar Association, Section of Mineral Law, 1949.) See also: North Bigbee, "Miracle in Oil" Dun's Review, December 1949, condensed in *Reader's Digest*, January 1950, under the caption, "Why We Aren't Running Short of Oil."

* * *

Filter manifolds at the Bailey salt water treating plant west of Kilgore. The filters are connected so that each unit can be backwashed without disturbing the flow through the other units. Capacity of the National Tank Company filters is 5000 bbl of water per day.

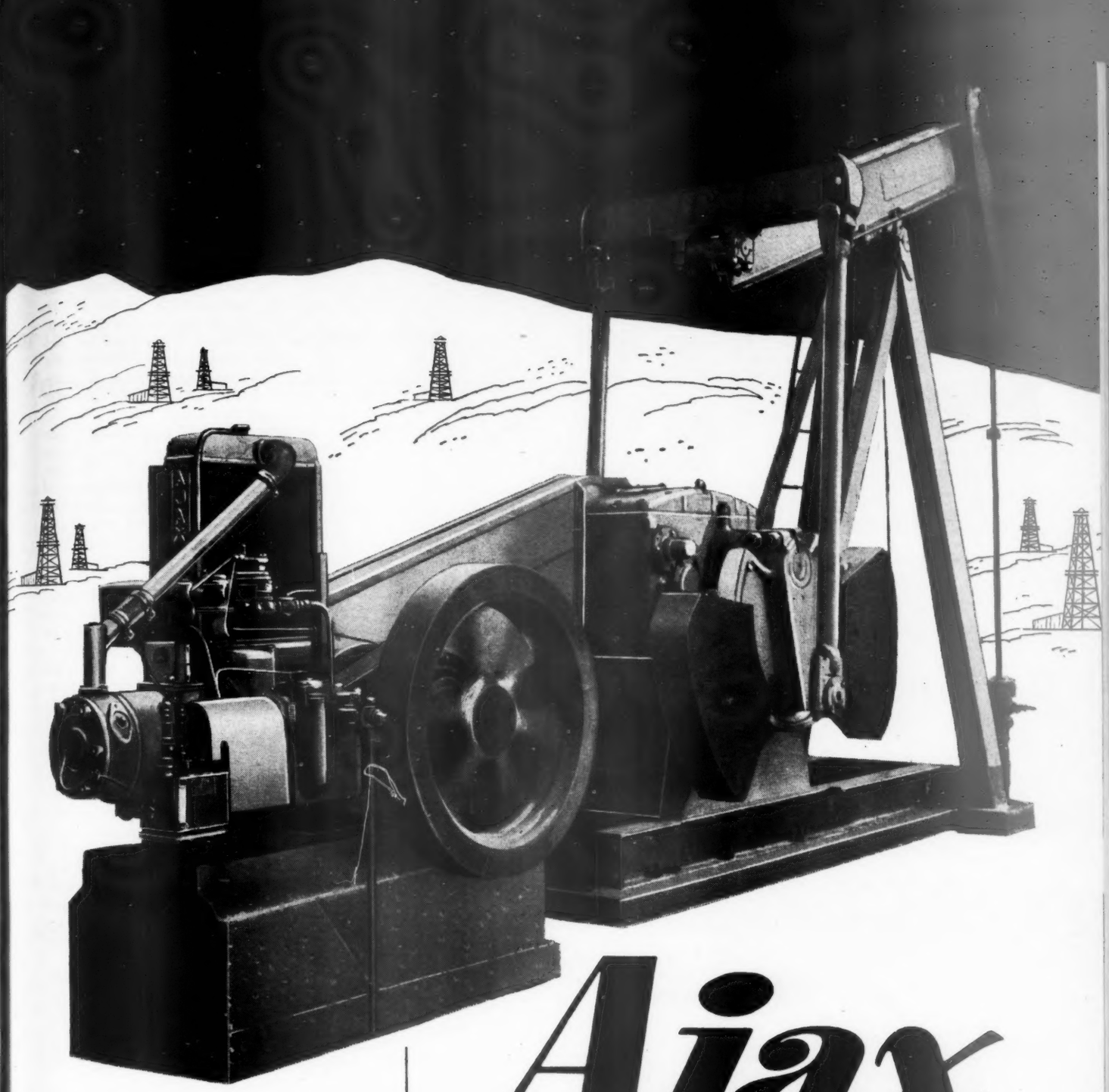

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FIG. 1.

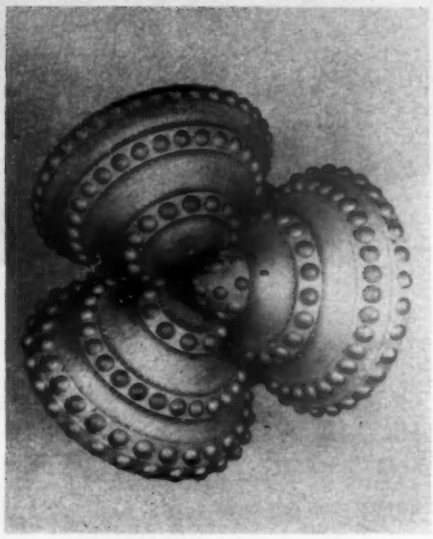

FIG. 2.

Improved Rock Bit Lowers Drilling Cost

Extensive research has gone into developing the right tool for the right job — Hard abrasive formations can now be penetrated

LYLE L. PAYNE

In recent years the search for deeper producing zones has introduced the serious problem of penetrating extremely hard and abrasive formations. Typical examples are the Devonian chert of West Texas or the bromides of Oklahoma. These formations cannot be economically drilled without applying adequate load on the bit to establish a destructive chipping-crushing action as the cutting surfaces rotate on bottom.

Lyle L. Payne
Chief Engineer
Hughes Tool
Company,
Houston, Texas

The problem of fortifying the cutting and gage surfaces of rolling cutter rockbits to better withstand abrasive wear encountered in many formations has been recognized from the year 1909. From this date until 1929, rockbit manufacturers depended entirely upon a carburized cutter to resist abrasive wear encountered in rotary drilling. Although periodic improvements in design materially increased the footage per bit and penetration rate, the abrasion problem was still unsolved.

During the year 1929 granulated cast tungsten carbide was first applied to the flanks of cutter teeth and the gage cutting surface. This material is extremely hard and highly resistant to abrasive action. Rockbits having an overlay of cast tungsten carbide applied to the cutting surfaces recorded marked improvement in performance, particularly in drilling abrasive formations of medium to low strength. The advent of tungsten carbide, in combination with improved metallurgy, alloy steels, and design, has been a major factor in the widespread use of rotary drilling.

The cast tungsten carbide application on the tooth flank of hard formation rockbits* is not effective in drilling extremely hard, abrasive materials which require heavy weight applied on the bit. Although this form of carbide is extremely hard and resistant to abrasion, it is also very brittle. This latter physical property limits its effectiveness as a protective overlay on hard formation rockbit cutter teeth when drilling formations under consideration.

In the past few years sintered carbide manufacturers developed remarkably tough grades for sustaining high-impact stress and still retaining high resistance to abrasion. This program, spurred by the desire of reducing the high cost of drilling chert, chert-bearing lime or dolomite, and hard, quartzitic formations, has led to the development of a special type rockbit.† Figs. 1 and 2 are a side and bottom view of the 8¾-in. type, and show the three conical cutters studded with hemispherical-ended cylinders of sintered carbide. The application of carbide cutting elements as represented by this bit has been field proved over the past two years.

The bit has given remarkable performance in the hard, abrasive cherty sections of West Texas and New Mexico, and the hard quartzitic formations of Oklahoma and the Rocky Mountain areas. It is not unusual for one bit to drill 3 to 10 times the footage normally obtained with regular hard formation rockbits in these hard, abrasive formations. The drilling rate will equal that of regular bits, and in some cases has exceeded the rate of regular bits by 50 per cent to 100 per cent.

The bit may be called a "spot" bit, but its application has been very rewarding in those localities where the "spots" are fairly well established. Experience has shown that not all formations classified as "hard abrasive," in which regular bits give relatively short runs, are economically drilled by this new type bit. Certain sandstones, which have relatively weak binders, and some hard, abrasive shales have not responded to the crushing action of the cutting structure. Apparently these formations, in place, must be somewhat plastic and are not friable. Field tests are necessary in determining the suitable formations for the bit.

Tables 1, 2, and 3 were compiled from bit performance records and show the average performance of the new type compared to the regular. Referring to Table 1, the average of 128 new type bits run and 89 regular bits run in the same formation shows the former has a footage ratio of 4.1 and a penetration ratio of 1.1.

Table 2 lists a limited number of runs. The footage ratio, however, of the new type is 3.6, and the speed ratio is 1.1. Table 3 lists comparative runs made in Oklahoma, and the average footage ratio of the new type is 2.9. The speed ratio is 1.4.

Table 4 lists part of the bit performance record of a well drilled in Upton County of West Texas. The formation was Devonian lime and chert. The two new type runs, compared to the regular, established a remarkable average footage ratio of 15 and a penetration ratio of 3.2.

The condition of the three bits listed in Table 4 is shown in Fig. 3. The cutting teeth and gage surface of the regular had served their useful life. The bit is well worn. The new type bits show moderate carbide breakage, but no appreciable wear off those compacts which are not chipped or broken, and they

*Such as the W7R.
†Hugheset type R1.

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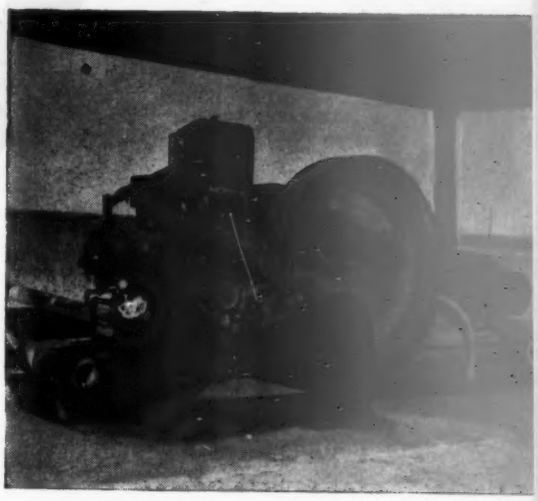

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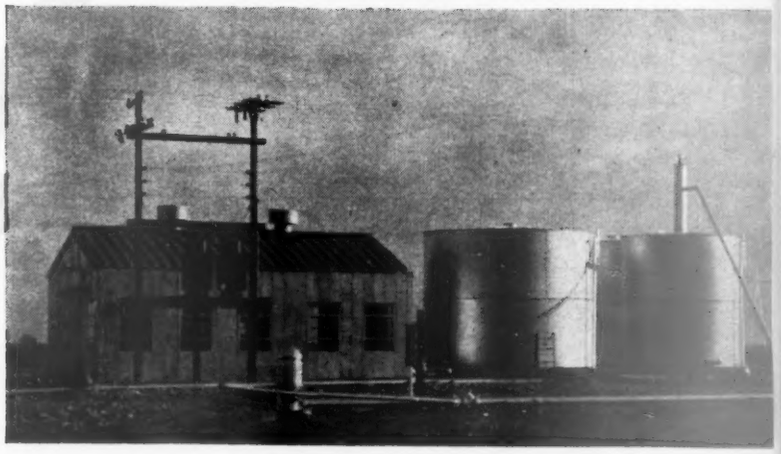

TABLE 1. West Texas and New Mexico.

Size bit	Bit type	No. Bits run	Total footage	Total hours	Average ft per bit	Average ft per hr	Ratio of footage	Ratio of speed
7⅞	R-1	9	442	162.75	49.11	2.72	5.0	1.6
7⅞	W7R	9	88	52.00	9.78	1.69		
6¾	R-1	2	104	56.75	52.00	1.83	5.5	1.5
6¾	W7R	2	19	16.00	9.50	1.19		
6¾	R-1	14	809	309.83	57.79	2.61	4.0	1.1
6¾	W7R	12	174	70.50	14.50	2.47		
8½	R-1	2	105	38.75	52.50	2.71	6.6	1.9
8½	W7R	1	8	5.50	8.00	1.45		
8¾	R-1	101	7695	2863.25	76.19	2.69	4.1	1.0
8¾	W7R	65	1245	464.75	19.15	2.68		
All sizes	R-1	128	9155	3431.33	71.52	2.67	4.1	1.1
All sizes	W7R	89	1534	608.75	17.24	2.52		

TABLE 2. Rocky Mountain.

Size bit	Bit type	No. Bits run	Total footage	Total hours	Average ft per bit	Average ft per hr	Ratio of footage	Ratio of speed
9	R-1	4	162	43.50	40.50	3.72	3.6	1.1
9	W7R	3	34	10.50	11.33	3.24		

TABLE 3. Oklahoma.

Size bit	Bit type	No. Bits run	Total footage	Total hours	Average ft per bit	Average ft per hr	Ratio of footage	Ratio of speed
9	R-1	11	530	229.78	48.18	2.31	2.9	1.4
9	W7R	11	183	106.76	16.64	1.71		

TABLE 4.

Size bit, in.	Type	Depth	Ft	Hr	Ft hr	Net	RPM
8¾	W7R	11,789	8	6½	1.23	35,000	40
8¾	R-1	12,922	133	31	4.29	40,000	35
8¾	R-1	13,030	108	30	3.60	35,000	35

FIG. 3. Shows condition of bits in Table 4.

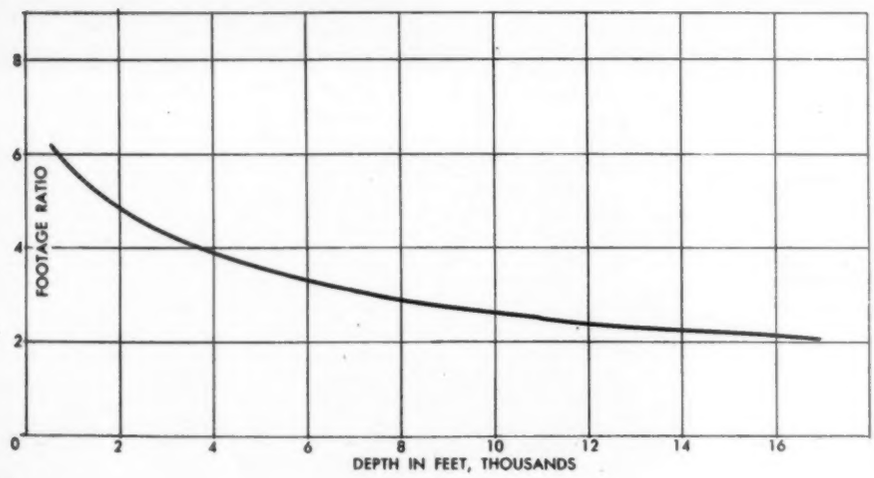

FIG. 4.

were pulled on the basis of relatively long rotating hours.

Operating Conditions

It has been found that the best operating practice in drilling chert or chert-bearing limestones is to carry weight on the bit of approximately 4000 psi of bit diameter, with a rotary speed of approximately 35 rpm. Extremely heavy weights in the range 5000-6000 psi of bit diameter are not necessarily economical. Weight applied on the new type, in excess of that required to establish effective chipping-crushing action on the formation, may materially reduce bearing life and also cause more breakage of the sintered compacts. A compromise applied load and relatively slow rotary speed will normally establish very smooth operation of the bit, which is highly beneficial to long bearing life, and consequently results in more footage per bit. The sintered carbide wears at a very slow rate and will maintain the initial penetration rate over a long period. Apparently only enough weight on the bit sufficient to effectively crush the formation is an optimum practice.

In certain instances the bit has been used in drilling a cherty dolomite with an applied bit load in the range 500-1000 psi of bit diameter. The footage ratio and speed of penetration ratio, compared to the regular type, were very satisfactory.

In some cases it may be necessary to ream an undersized hole before reaching bottom with the bit. Such reaming should be performed under careful control to avoid imposition of large inward thrust forces, which may cause breakage of the gage-cutting, sintered compacts. It is recommended that reaming be performed at a controlled rate and not exceed ten feet per hour. Furthermore, it is advisable to check periodically the applied torque by disengaging the rotary table drive clutch. Excessive "wind-up" of the drill stem indicates the bit is not reaming freely, and the drill stem should be raised to permit re-reaming at a slower rate. In reaming an appreciable footage of extremely hard, abrasive formation the bit may become undersized and would, upon reaching bottom, drill undersized hole. Such cases may warrant a round trip to change bits in order to drill ahead with a full gage bit.

The greater footage obtained in suitable formations has paid handsome dividends by reducing round trips, thereby saving rig time and wear on equipment. The curve shown in Fig. 4 will give an appreciation of this result. Under the assumed conditions, the footage ratio required of the new type bit was calculated to equal a regular bit's cost per foot of hole drilled at various depths. A brief study of this curve shows the new type will lower drilling cost in suitable formations even at moderate depths, but particularly in deep drilling.

Continuing research and development is under way directed at further improvement of the present new type design, and to extend the basic principle of the bit into modified designs for drilling other abrasive formations of moderate strength. ★ ★ ★

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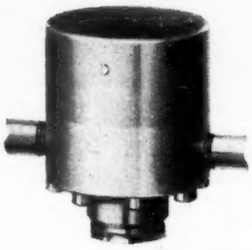

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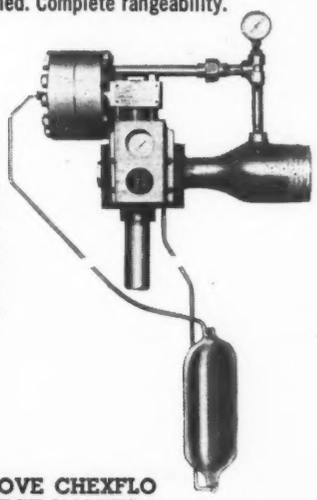

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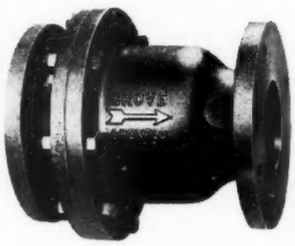

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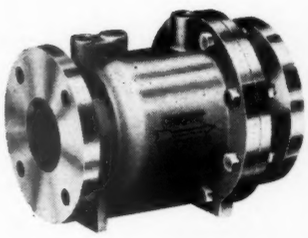
Full-flow valves, utilizing the Grove expansible tube principle. Line flow holds the tube off its seat—as flow diminishes, the tube contracts. When flow stops, the tube constricts shut, preventing reverse flow.



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Expansible tube type valves, pilot controlled for pressure reducing, back pressure or relief services. Compact, quiet. Positive, bubble-tight shut-off. No metallic moving parts to corrode or stick.

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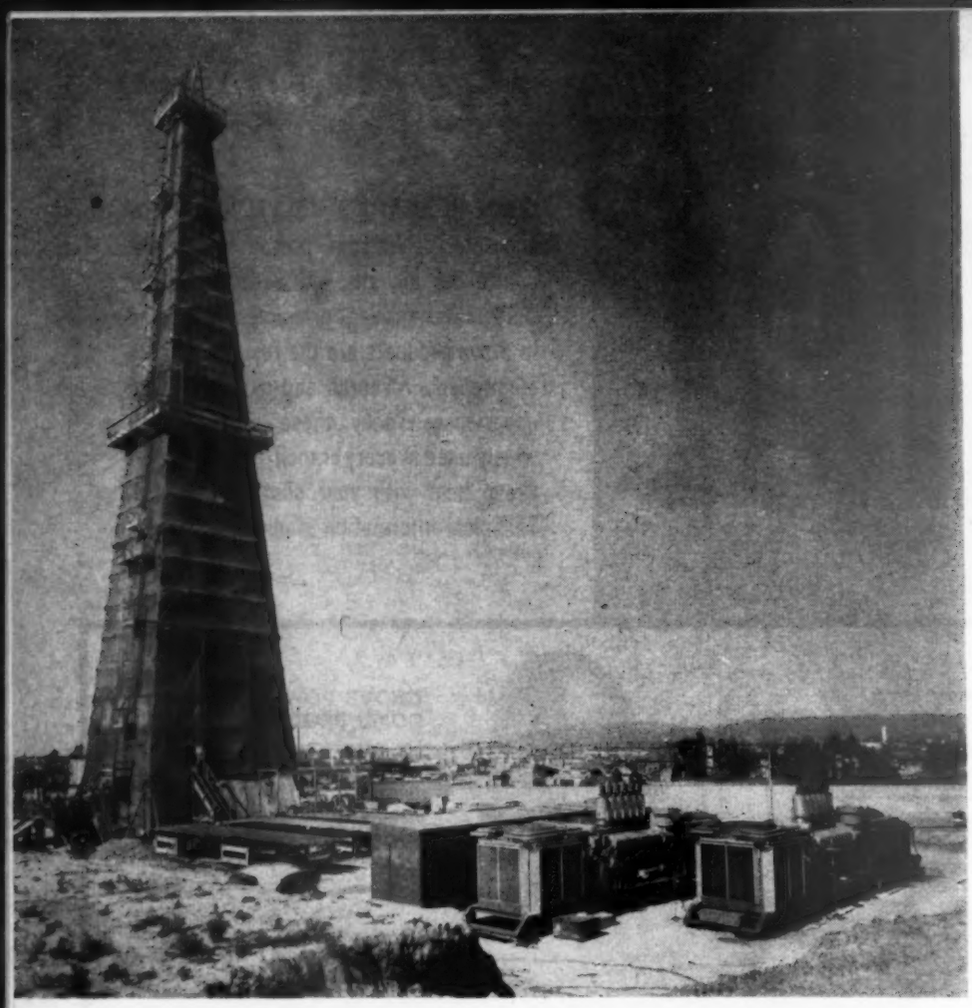


P 422.141

Standard of California's new diesel electric rig drilling its first hole. The 162-ft derrick is fully insulated.

EXCLUSIVE

DIESEL-ELECTRIC RIG

Standard of California has incorporated power, portability, and flexibility — keys to less lost time

AN unconventional diesel-electric rig developed for faster, deeper drilling, shows promise of becoming one of Standard Oil Company of California's better contributions to the drilling and producing progress of recent years.

Power, portability, and flexibility of control comparable to a steam rig are the objectives of the rig, three characteristics Standard of California feels are essential to economical drilling of the deeper holes normally encountered in California field operations.

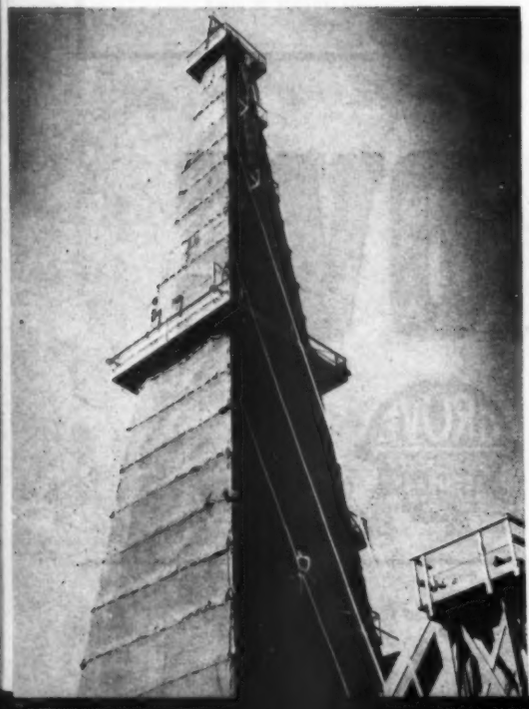
The rig's 2400 hp is considerably more than that of the average heavy drilling unit. Standard engineers expect it to be used on infrequent deep tests from 15,000 to 20,000 ft, as well as everyday drilling from 8000 to 12,000 ft.

One of the most unusual things about the rig is its "finger-tip" control panel. Seated at a console in one corner of the drilling floor, the driller controls the entire operation by manipulating a bank of knobbed levers.

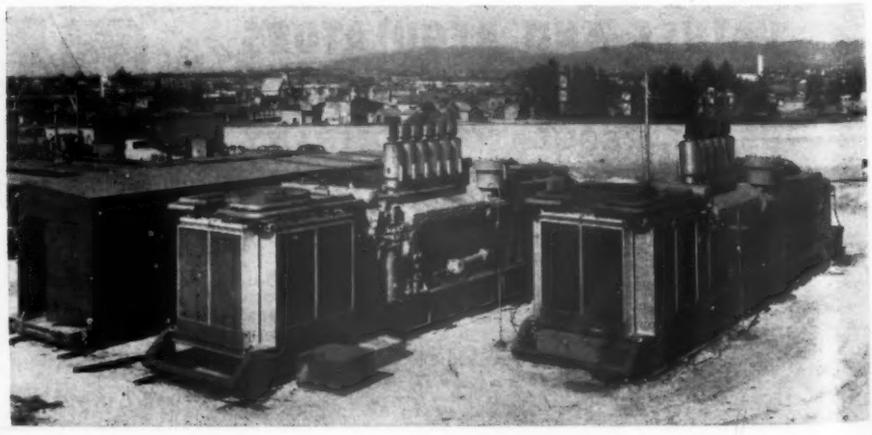
No longer does the driller stand alongside the drawworks, hauling on long levers and stepping on foot pedals. Dials and winking lights give instant information and warnings on every procedure. Amplidynes give exact and instant response.

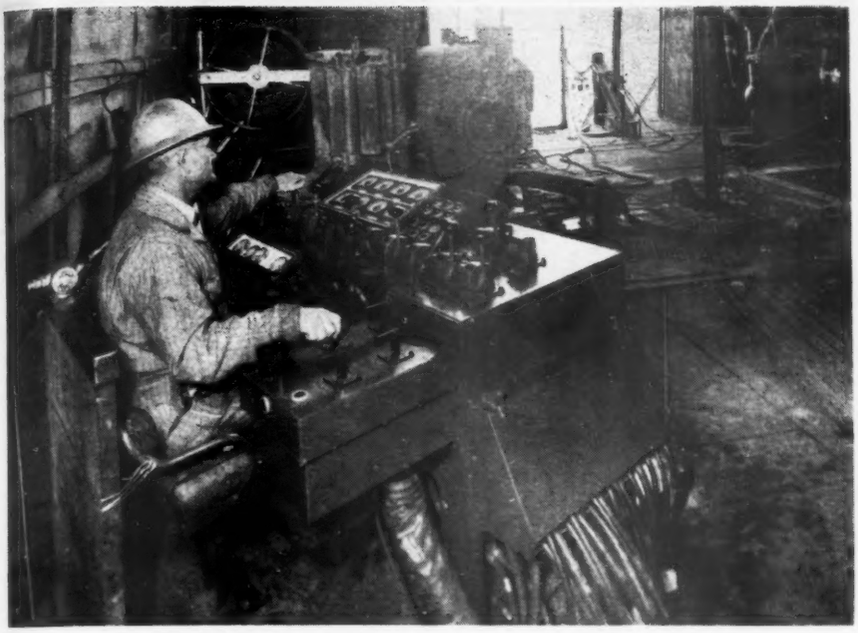
The rig represents an expenditure of nearly $400,000, exclusive of drill pipe, derrick, substructure, and miscellaneous equipment. The power plant of two diesel engines, six generators, and four d-c motors were salvaged from World War II Navy vessels. To duplicate the rig with new equipment would have added about 75 per cent to the cost.

No outside source of electric current is required. The two diesels, each 1200 hp, drive the d-c generators to supply power for drawworks, rotary, mud pumps, and other uses. The generators are divided into sets of three, each consisting of one 1200 kw-525 v, for driving the drawworks and mud pumps; one

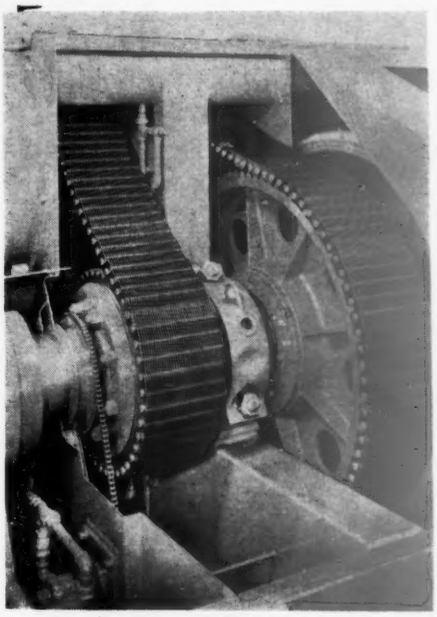


Top of derrick at left and below two 12-cylinder 750 rpm locomotive type engines utilized for powering various direct current generators. Relatively low speed diesel engines permit use of inexpensive industrial type diesel fuel.





Looking across derrick floor from driller's console. The derrick floor is clear of everything except driller's console, rotary table, and catworks. The drawworks is located at ground level under derrick floor.



Revolutionary "HY-VO" chain drive used in drawworks provides maximum load capacity per unit of width and greatly minimizes noise, vibration, and shock loads on chain links.

300 kw-230 v, for driving the rotary table; and one 150 kw-125 v for powering auxiliary units and amplidynes.

During normal drilling, either of the two sets may be functioning. For hoisting service, however, the driller parallels the two 1200-kw units to drive the 1500-hp drawworks motor.

This provides 29,000 lb of high gear fast line pull and, with eight lines strung, approximately 10,000 ft of 4½-in. drill pipe can be started from bottom in high. Use of d-c motors enables fast and even acceleration.

An unusual design characteristic of the rig is the setting of the drawworks at ground level under the derrick floor. This eliminates the necessity for a heavy substructure to support the unit.

An indication of the capabilities of this new rig can best be obtained from the progress records of the wells drilled thus far.

The first well, Vickers 2-18, near Inglewood, California, was drilled to 9200 ft in 51 days. The best recorded drilling performance for comparable rigs in the area is 34 days to 8400 ft. Standard's diesel-electric rig reached the latter depth after 35 days. Had the time required for setting casing been equal in these two wells, however, the drilling time for the diesel-electric rig would have bettered the time for the fastest recorded well by three to five days.

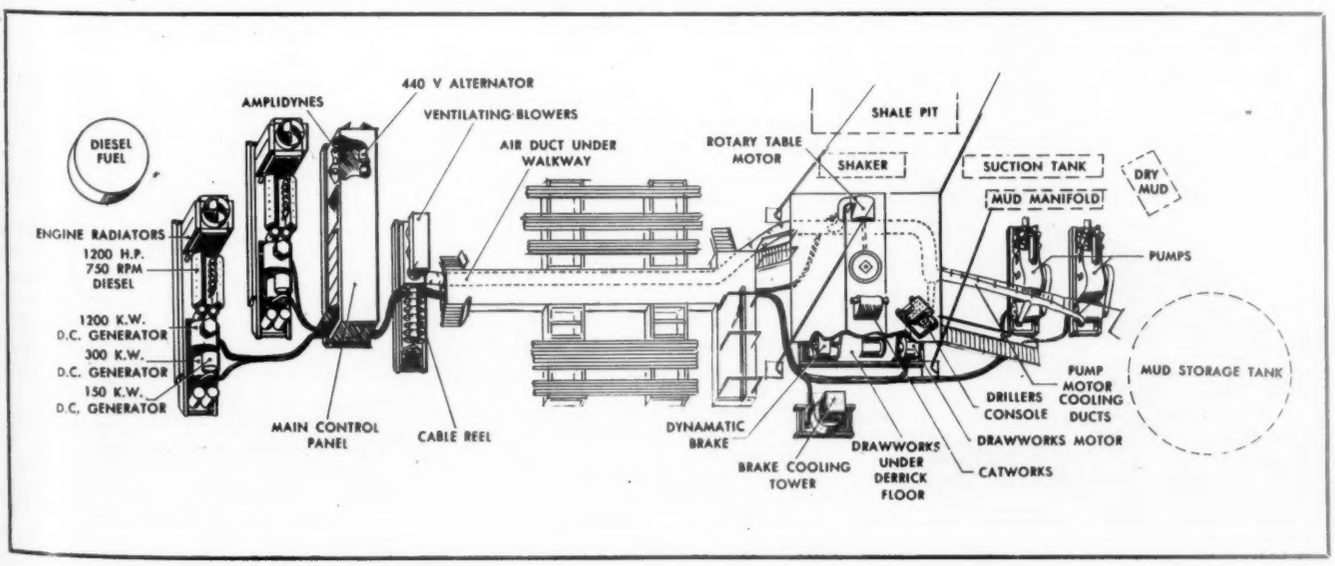
No engineering evaluation was made of the drilling progress in the first well but the high drilling rates are unofficially ascribed to the speed and flexibility of the rig and the high mud volumes obtainable with paralleled pumps.

The drilling rate for the second well, Walker No. 25, in the Santa Fe Springs area, was also greater than the fastest recorded rate for other wells in the region. This record is approximately 8000 ft in 28 days, exclusive of delays for testing and setting casing. The diesel-electric rig's time for the same interval (also exclusive of the same delays) is about 27 days.

A third well, Emery 92, near La Habra, is now being drilled but no data are available at present for evaluation of rig performance.

Bit weight, being a function of drill collar weight, has not been a factor in the evaluation of performance. The overall drilling speeds are affected by mud pump volumes and rotary and hoisting speeds.

The 500-hp rig pumps are driven by 765-hp amplidyne controlled d-c motors



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Sizes from ½" through 6" and up to 400' long.

PLASTEX PIPE
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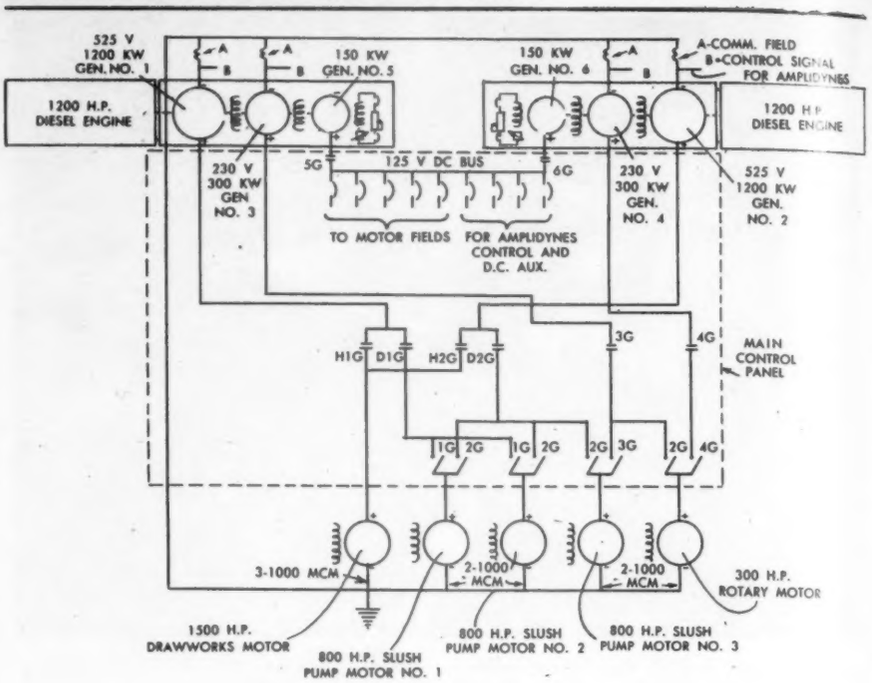

MAIN POWER SCHEMATIC

that may be paralleled as required. The large hydraulic horsepower available with this arrangement and the use of jet bits are considered the primary reasons for the higher drilling rates. No detailed time study of performance has been made, however, as the wells drilled thus far fall below the maximum depth rating of the rig and considerable testing and adjustments have been necessary.

Operational costs of the diesel-electric rig have been generally higher than those of comparable units, mainly because of problems arising out of the use of war surplus equipment. Much of the surplus equipment had to be re-designed for drilling rig application and some "bugs" have to be corrected.

Normal repetitive maintenance and servicing, however, has been accomplished with the same mechanic-electrician coverage employed on Standard of California's other power rigs. So the company believes that ultimately operating costs will be lower than those of conventional rigs.

As noted above, one of the primary purposes behind the development of the rig was to obtain greater portability for a deep-drilling rig. As a consequence all mechanical and electrical units are skid mounted and completely self-contained so that tearing down and moving operations will require a minimum of time.

The 11 packages comprising the main rig components were designed, wherever practicable, to comply with state regulations governing highway travel. All units are easily handled by conventional cranes and oil field trucks.

To date the moving has averaged about $15,000 a well — approximately the moving costs for ordinary rigs of the same size. Lower rig-up costs are expected on future moves as the two moves to date have required long trips between fields and only limited rig up experience has been acquired thus far.

Personnel and equipment on the rig are protected by many safety devices, among which are alarm lights at the driller's console, indicating excessive motor currents, and safety relays preventing engine over-speed. A forced air ventilating system to all generators and motors eliminates explosion hazards and keeps motors at safe operating temperatures.

The drawworks brakes are entirely air operated and a spring loaded brake is provided for emergency use. The latter brake is connected to the air supply so that if air pressure falls below 80 psi it engages automatically.

As a final innovation, the 150-ft rig can be covered with heavy brown canvas quilting, stuffed with strips of sound-deadening material, for operation near inhabited areas. High walls of the same material can be placed between engines and generators and the heavy motors are equipped with silent chain drives.

With its new diesel-electric equipment, Standard of California hopes to undertake the exploration of deeper frontiers of possible oil-bearing strata more easily and economically than ever before. * * *

Mr. Fairless's Take-Home Pay

In spite of advances in salary, Benjamin F. Fairless's "take-home" pay has been reduced. In 1940 the salary of U. S. Steel's chairman and president was $139,610. In 1951, it was $261,000. The increase was 88 per cent. However, after payment of income taxes, the increase was converted into a decrease. His 1940 salary, after taxes, was $75,291, and his 1951 salary, after taxes, was $72,054.—*U. S. Steel News.*

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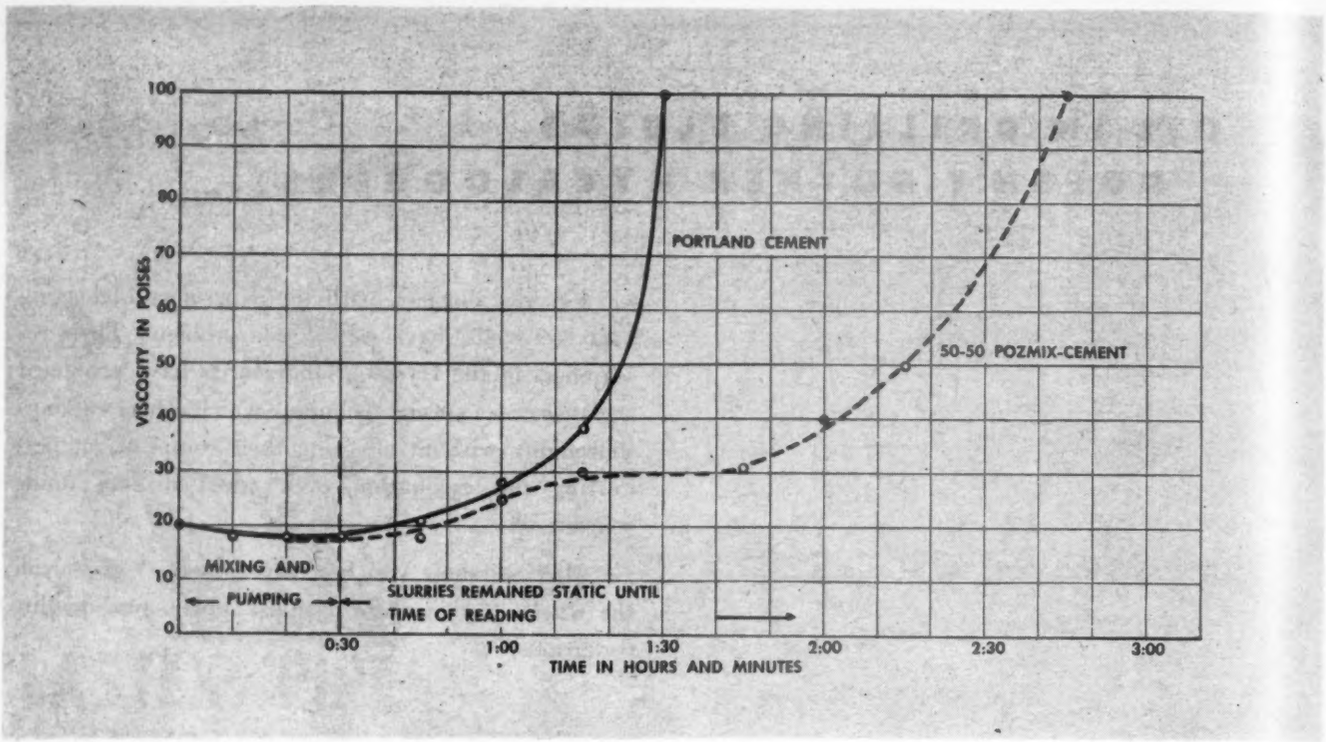


FIG. 1. Slurry viscosity vs shut down time. Temperature at 100 F.

New Material for Cementing Wells

Greater penetration and less shattering of the cement when perforating are among advantages of new product

CALVIN D. SAUNDERS and BOB DIGGS BROWN*

For the past 25 years or more, portland-type cement has been the standard material employed for cementing casing in oil wells. The purpose of oil well cement is to anchor the casing in place and to prevent the migration of fluids in the annular space between the casing and the formation. Neat portland cement slurries containing only the cement and water have been employed most extensively in oil well cementing operations to date.

Although portland-type cements have been by far the most successful material for cementing oil wells, they are not without some undesirable characteristics among which the following are most notable:

1. A neat cement slurry, in many instances, has a higher density than is desirable.
2. Neat cement is susceptible to the corrosive action of sulfate waters and will disintegrate in time in the presence of some oil field formation brines.
3. Set, neat cement having a high strength is usually quite brittle and tends to shatter when perforated. Also, the depth of penetration of perforators is much less in high strength cement than in a low strength.
4. Slurries made with only cement and water have rather fixed properties that can not be altered to meet different requirements. Additional agents are needed to give cement slurries more flexibility so that various conditions can be successfully met as the occasion demands.

The above undesirable properties of neat cement, as used in the petroleum industry, have been recognized and research work has produced additives such as bentonite, expanded perlites, and others in an effort to approach an ideal cementitious material.

Further research has indicated that pozzolanic materials have a place in oil and gas well cementing.

A pozzolan is defined as a silicious material, which in itself possesses no cementitious quality, but will, in the presence of moisture, combine with calcium hydroxide to form insoluble compounds that exhibit cementitious properties. Many pozzolanic materials exist, but all are not suitable for use in cement mixes as determined by laboratory analysis.

Natural pozzolans are primarily materials of volcanic origin, although some diatomaceous earths have pozzolanic properties. Artificial pozzolans are main-

*Halliburton Oil Well Cementing Company.

EXCLUSIVE

ly materials obtained by the heat treatment, or calcination, of natural clays, shales, and certain silicious rocks. Combustion-by-products of certain natural materials have also been found to be pozzolanic in character.

Pozzolanic materials have been used for over 2000 years in construction work. Many structures built by the ancient Romans, Greeks, and Aztecs can, to this day, be seen in wonderful states of preservation. These alone attest to the lasting quality of pozzolanic cements.†

Pozzolans also have a respectable history in the United States. Cement for the Los Angeles Aqueduct (1910-1912) was interground with a slightly active volcanic ash, and pumicite was employed in an experimental way in two dams of the Los Angeles Flood Control District in the twenties. But the real beginning of pozzolans in America dates from Bonneville Dam. Since that time, knowledge of these useful materials has greatly increased.[1]

All available literature on the use of pozzolan as an additive to cement, concrete, and mortar indicated the advantageous properties of the material could be readily adapted to oil well cementing slurries. The primary properties were:

1. Compatibility with cement.
2. Lower density of the dry material.
3. Less leaching of soluble components.
4. Lower permeability of set material.
5. Improved resistance to corrosive waters.
6. Slower strength development.
7. Lower heat of reaction.

Compatibility With Cement

Some pozzolans, both artificial and natural, having a fineness comparable to cement can be blended with the cement in almost any proportion desired. The ratio of pozzolan to cement being dependent on the conditions under which it is to be used.

The nature of some of the pozzolans is such that, when the cement and pozzolan in the blend are of approximately the same fineness, the water requirements for preparing a given consistency slurry is fairly comparable to that for neat cement.

The term "pozzolan cement" as used in the remainder of this article applies to a blend of pozzolan and commercial portland cement regardless of the percentage of each component.

Laboratory tests also have revealed that pozzolan cements are compatible with other cement additives that are currently being used such as calcium chloride, salt, lost return materials, and others. The action of these additives on pozzolan cements is very similar to the action on neat cement slurries.

Lower Density of Dry Material

Pozzolans have a specific gravity of 2.2 to 2.8, depending upon the source, as compared to 3.1 to 3.2 for portland cements. This difference in specific gravity results in a slightly lower weight for the pozzolan cement slurry than for a slurry of the same consistency with portland cement.

†The trade name is "Pozmix."

The Authors

C. D. Saunders

Bob Brown

Calvin D. Saunders graduated in 1943 from the University of Oklahoma with a B.S. degree in chemical engineering. He served 3 years in the Army during World War II seeing action in the European Theater. He began working in the laboratories of the Halliburton Oil Well Cementing Company in 1946. In 1948 he became section leader of the cement-mud section in which capacity he is still serving.

Bob Diggs Brown received his B.S. degree in mechanical engineering at Oklahoma A & M College in 1941. The same year he joined the Halliburton organization, assigned to the Mechanical Research and Development Section with the Engineering Department. From 1941 ot 1945 he was in service, then rejoined the Halliburton organization in the MRD Section. Since 1948 he has been assigned to the Evansville Division as division engineer.

Improved Resistance to Corrosive Waters

As stated above, pozzolanic materials require calcium hydroxide to harden. When portland cement hydrates, calcium hydroxide is formed. This chemical in itself contributes nothing to strength or water tightness and is readily removed by leaching. When a pozzolan is present, however, it combines with the calcium hydroxide contributing both to strength and water tightness.[2]

By this means the soluble components of the cement, which are subject to leaching are reacted with the pozzolan so that the number of possible entries into the cement by corrosive waters is lowered considerably. Therefore, detrimental sulfate waters can not readily enter the cement in order to react with the components of the cements.

Concretes containing pozzolans have been found to be more resistent to weakly acid waters. Such concretes are not totally immune from acid attack, but through the use of pozzolans the rate of attack is greatly decreased.[3]

TABLE 1. Slurry weights and volumes.

Pozzolan-Portland Cement*

Per cent mixture		Water solids ratio	Water-gallon per sack of mixture	Slurry weight, pounds per gallon	Slurry volume cubic feet per sack
Cement	Pozmix "A"				
100	0	0.46	5.20	15.4	1.18
75	25	0.55	5.82	14.6	1.26
50	50	0.56	5.63	14.3	1.24
40	60	0.56	5.45	14.2	1.22

* ASTM Type I Cement.

Note: The above data were obtained on one brand of this particular type of cement and may or may not be representative of data obtained on other brands of this type cement.

Impermeability

Use of pozzolans in appropriate amounts greatly increase water tightness of concrete. The coefficient of permeability for lean mixes at the later ages is generally only a small fraction of that for corresponding mixes that contain straight portland cement.[2]

Slower Strength Development

At early ages concretes containing pozzolans exhibit lower strengths, but as the cement ages under moist conditions the strength of pozzolan cement concretes, and mortars will approach or may exceed the strength of corresponding concretes or mortars that are prepared with straight portland cements.[3,4,5]

Lower Heat of Hydration

The addition of pozzolan to cement lowers the amount of heat generated by the hydration of a given volume of cement slurry and also liberates this heat at a slower more favorable rate. The pozzolanic reaction itself liberates heat, but this heat is considerably less than that of an equal weight of cement.

Each of the above listed properties was apparently advantageous for use in oil well cementing slurries. Experimentation was begun in 1949 to determine which pozzolan, or pozzolans, would produce the most satisfactory cementing slurry properties, and eliminate or reduce to a minimum the inherent limitations of neat cement slurries.

Laboratory Evaluation

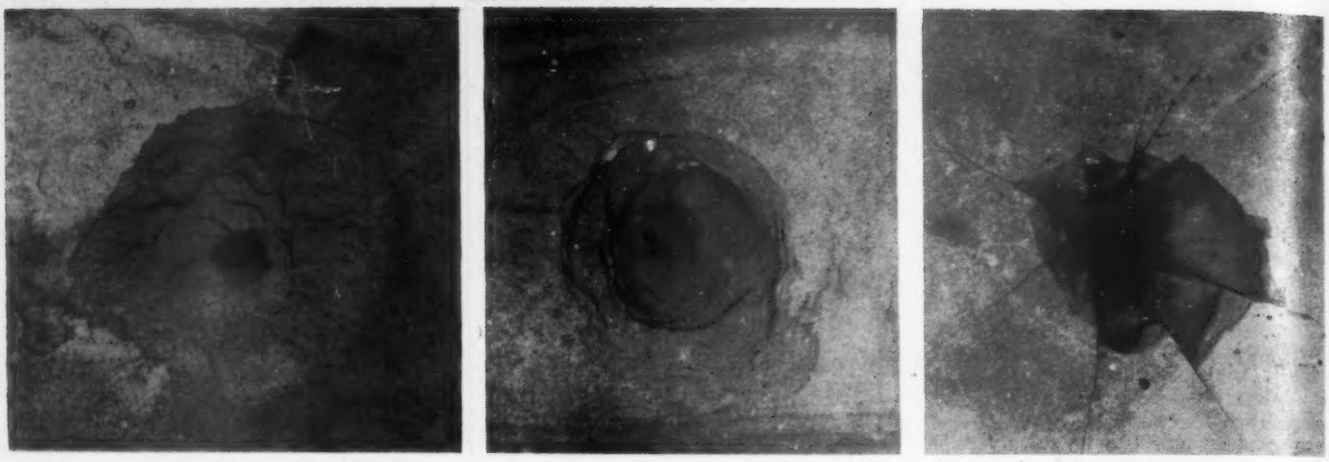
A great many natural and artificial pozzolans were obtained and evaluated for use. Two materials appeared to be satisfactory from the standpoint of physical properties, availability, and economics. One of these was a natural pozzolan and the other an artificial pozzolan, each having similar properties when used with portland cement.

As the properties were quite similar the data given herein are for the artificial pozzolan. The main difference between the two pozzolans is in the density of the materials, which slightly changes the weight ratios of cement and pozzolan for the various blends.

Table 1 gives slurry properties of various pozzolan cement mixtures. The mixtures are based on per cent by absolute volume; that is, one sack of portland cement has a bulk volume of 1 cu ft and an absolute volume of 0.48 cu ft. One sack of 50-50 blend contains enough cement to occupy 0.24 cu ft, and enough pozzolan to occupy 0.24 cu ft, thus keeping the absolute volume of a sack of blend equivalent to that of a sack of cement. This amount was found to be the optimum for greatest field mixing control.

The slurry weights are decreased while the slurry volumes remain fairly consistent with an increase in pozzolan.

The thickening time data given in

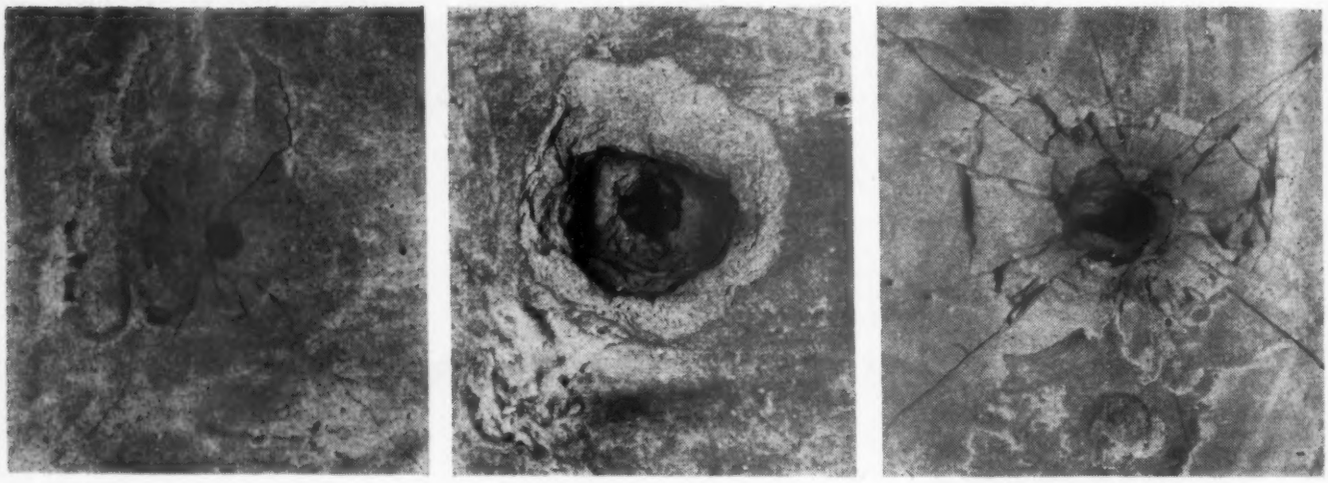


Pozmix "S" — 50%
Portland cement — 50%

Pozmix "A" — 50%
Portland cement — 50%

Pozmix — 0%
Portland cement — 100%

FIG. 2. TEST PANELS CURED FOR 1 DAY AT 100 F BEFORE PENETRATION WITH HOWCO GUN PERFORATOR.

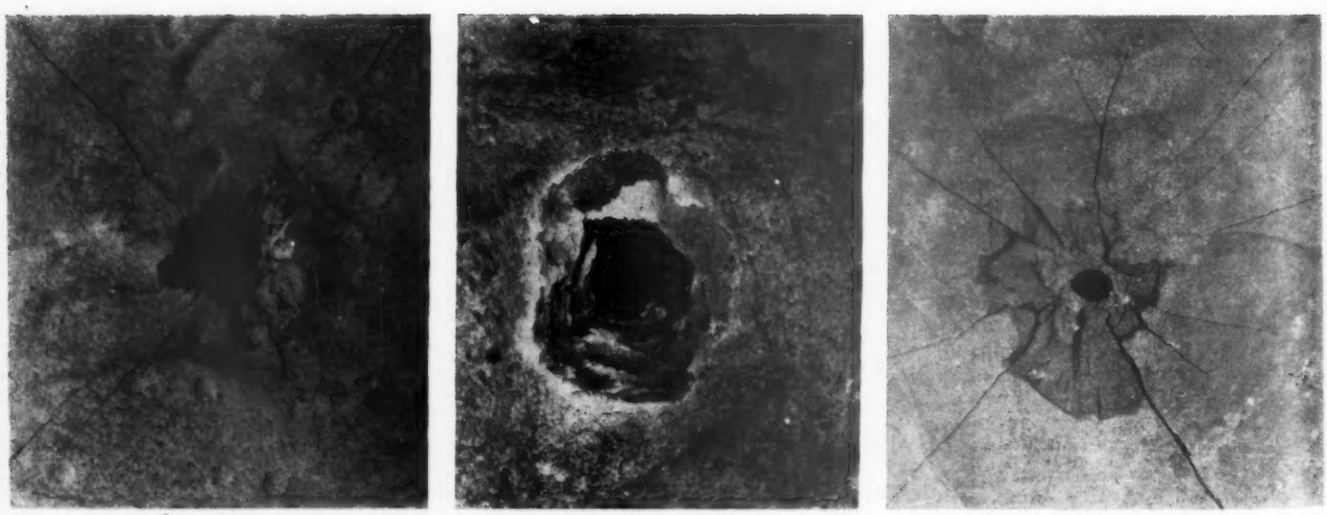


Pozmix "S" — 50%
Portland cement — 50%

Pozmix "A" — 50%
Portland Cement — 50%

Pozmix — 0%
Portland cement — 100%

FIG. 3. TEST PANELS CURED FOR 3 DAYS AT 100 F BEFORE PENETRATION WITH HOWCO GUN PERFORATOR.



Pozmix "S" — 50%
Portland cement — 50%

Pozmix "A" — 50%
Portland cement — 50%

Pozmix — 0%
Portland cement — 100%

FIG. 4. TEST PANELS CURED FOR 7 DAYS AT 100 F BEFORE PENETRATION WITH HOWCO GUN PERFORATOR.

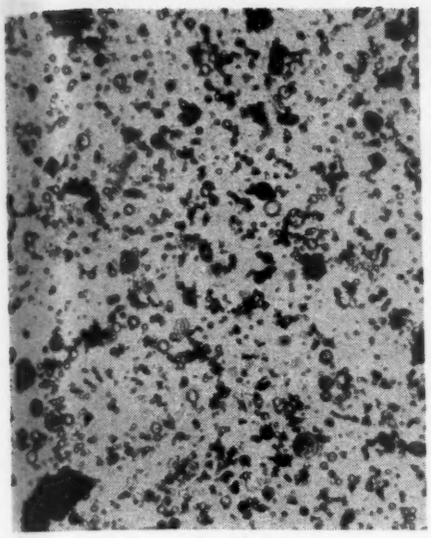


FIG. 5. POZMIX "A"

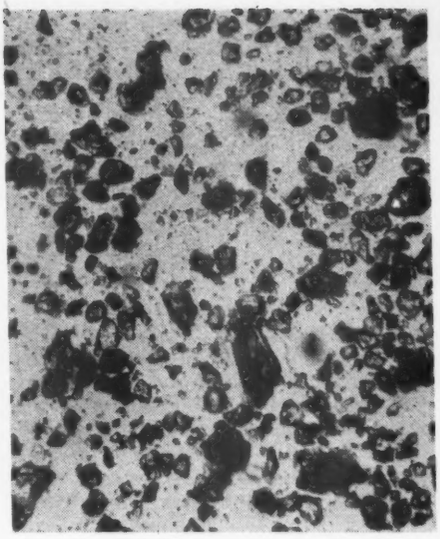


FIG. 6. PORTLAND CEMENT

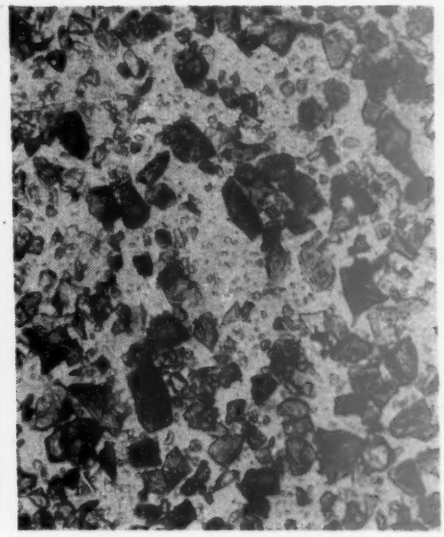


FIG. 7. POZMIX "S"

Table 2 show that the available handling time is very nearly the same regardless of the per cent mixture being used. These tests were made according to the test schedules outlined in the API Code No. 32, "Testing Cements Used In Wells."

Early compressive strengths (Table 3) of the mixtures decrease with an increase in per cent pozzolan, but, as shown by Farris[6], these lower strengths are sufficient to hold pipe rigidly in the hole, and the high strengths obtained with neat cement are not necessary.

The lower strengths obtained at the early ages were an advantage when specimens were perforated with bullets. The results of these tests can be seen in Figs. 2, 3, and 4. As with all cement mixtures, the amount of shattering by perforating increases with an increase in strength of the set material.

Bonding strengths of pozzolan cement to pipe were found to approach that of neat cement after seven days curing, although the one, and three day results were slightly lower (Table 4).

These data given are for portland (ASTM Type I) cement, but data obtained on other types of cement, excluding those containing chemical retarders, follow the same trend shown here.

A freshly prepared neat cement slurry remains at a fairly low consistency during agitation. When agitation is stopped for a period of time the slurry gels so that additional force must be applied to start again the fluid movement. Fig. 1 shows a comparison of a neat cement slurry, and a pozzolan cement slurry after periods of static condition, i.e., no agitation of the slurry.

Both slurries were stirred for 30 min at which time the agitation was stopped. After various periods of time without agitation, the viscosity of the slurries was determined until a viscosity of 100 poises was reached, which is considered to be the limit of pumpability.

At 100 F the true thickening time of both slurries would be in excess of 2 hr 30 min. Therefore, the gelling action of the neat cement could be detrimental should movement of the slurry be stopped, whereas with pozzolan cement the movement could be resumed after considerably longer periods of shutdown with no appreciable increase in pressure.

TABLE 2. Thickening time—hours: minutes.

Pozzolan-Portland Cement*

Per cent mixture		Simulated well depth		
Cement	Pozmix "A"	2000 ft	4000 ft	8000 ft
100	0	4:30	2:59	1:42
75	25	4:01	2:56	1:52
50	50	4:01	3:17	1:53
40	60	4:41	2:33	1:57

*ASTM Type I Cement.

Note: The above data were obtained on one brand of this particular type of cement and may or may not be representative of data obtained on other brands of this type cement

TABLE 3. Compressive strength — psi — 24 hours.

Pozzolan-Portland Cement*

Per cent mixture				
Cement	Pozmix "A"	80 F	100 F	140 F
100	0	1710	2660	4300
50	50	370	510	920
40	60	260	330	630

*ASTM Type I Cement.

Note: The above data were obtained on one brand of this particular type of cement and may or may not be representative of data obtained on other brands of this type cement.

Field Tests

The results of the laboratory tests relative to the application of a pozzolanic cement for oil well servicing, indicated field tests were in order.

The Illinois, Indiana, and Kentucky area was chosen as the locality for the field tests as the following conditions would be encountered:

1. Several pay zones may be completed with one string of pipe by the use of Securaloy sections, or windows as they are sometimes called.

2. The spacing between Securaloy sections varies and may be as close as 30 ft.

3. Removal of Securaloy sections generally includes the use of caustic nitrate solutions followed by nitroglycerine as a zone completion program.

4. The common practice is to treat selectively closely spaced lime breaks through perforations with acid.

5. A relatively small amount of cement is involved for the production string.

A total of 21 field tests was conducted with 4248 sacks of pozzolanic cement. In all cases, a 3 per cent bentonite content was used based on cement involved in the mixture.

Two wells were completed with a 25 per cent pozzolan—75 per cent cement mixture for a total of 700 sacks of mixture; 18 wells were completed and one squeeze job was performed with a 50 per cent pozzolan—50 per cent cement mixture for a total of 3548 sacks of mixture.

An analysis of the wells completed with pozzolan cement reveals 70 per cent were shot with nitroglycerine, 15 per cent were completed natural, 10 per cent were acidized through perforations and 5 per cent were acidized below casing seat. Satisfactory results were obtained in all cases with the exception of one well that required a subsequent

TABLE 4. Bonding strengths. Pounds per square inch of bonded surface.

Pozzolan-Portland Cement*

Temperature F	0–100	25–75	50–50	66–33
		1 Day Cure		
80	110	100	80	60
140	210	180	160	140
170	230	200	200	170
		3 Day Cure		
80	190	190	130	100
140	185	240	160	200
170	189	210	160	120
		7 Day Cure		
80	200	230	200	180
140	220	230	190	160
170	240	230	220	180

*ASTM Type I Cement.

Note: The above data were obtained on one brand of this particular type of cement and may or may not be representative of data obtained on other brands of this type cement.

squeeze job, which was primarily the result of a poor mud condition.

The field tests were conducted with the cooperation of three major oil companies who would permit certain reasonable tests to be run during the cementing job. It was found a "shut-down-viscosity" test such as conducted in the laboratory, reference Fig. 1, would prove most informative under actual field conditions.

The first "shut-down-viscosity" test was conducted with a 50 per cent pozzolan-50 per cent cement mixture. The top plug was pumped with 350 psi to within 100 ft of the float collar with the mud pump. At this point, the plug was stopped for 30 minutes. At the end of this time interval, the pump on the cementing unit began displacing the plug to the float with a maximum pressure of 340 psi.

The second "shut-down-viscosity" test was made using 25 per cent pozzolan-75 per cent cement slurry. A mud pump pressure of 300 psi was required to land the plug within 100 feet of the float collar. After 75 minutes, 500 psi was required for initial movement with a final pressure of 375 psi to land the plug on the float.

Research work[2,3,4] proved pozzolan cement slurries have a slightly lower heat of hydration than a neat cement slurry; however, this factor introduced consideration of locating the top of cement by the use of a temperature survey. The top of the pozzolanic cement was located with temperature surveys 12 hr after landing the top plug on six wells whose bottom hole temperature was within the range of 90-100 F.

The six wells proved the heat of hydration of a pozzolan cement slurry was sufficient to locate accurately the top of the set material in a relatively low temperature reservoir, thus confirming the laboratory data and indicating the same information could be obtained in areas of higher bottom hole temperature.

It was evident, from laboratory as well as field tests, the success of this material would depend upon the efficiency of the bulk plant to obtain the proper dry mix. The importance of the dry mix led to modification and redesign of bulk plant equipment to allow the material to be placed on a commercial basis.

The field tests proved that the present bulk conveys and conventional mixing procedures were adequate for handling and mixing of pozzolan cement slurries.

The field tests of the pozzolan cement confirmed many of the laboratory data. It was realized many of the desirable characteristics of this material could not be fully evaluated until several years after the wells were cemented; however, the 21 wells indicated the flexibility of the pozzolan cement, which was highly acceptable by the companies for whom the wells were serviced.

In May, 1951, a blending plant was completed in Flora, Illinois, and the pozzolan cement was offered to the industry on a commercial basis. From May, 1951, through April, 1952, a total of 139,411 sacks of the pozzolan cement had been used within the Illinois, Indiana, and Kentucky area. A breakdown of jobs is given in Table 5.

TABLE 5.

Type	Jobs	Sacks	Average sacks
Surface	13	2,632	202
Oil string	489	98,374	201
Squeeze	68	10,733	158
Plugback	16	1,395	87
Plug-to-abandons	117	12,603	108
Liners	5	535	107
Miscellaneous	79	13,139	190
Total	787	139,411	177

The general characteristics of pozzolan cement to offer greater resistance than neat cement to waters of high salinity and sulfates has been well received. In many water flood operations where the life expectancy of the flood is from 10-20 years, pozzolan cement has been used in injection and producing wells as a precautionary measure to reduce possible future remedial work, which might result from corrosive waters behind the pipe.

Pozzolan has been used in cementing operations for plug to abandon, plugback, and surface pipe as a protective measure against migration of undesirable fluids and to protect coal seams.

From Table 5, it may be noted that 68 squeeze jobs have been performed using an average of 158 sacks of pozzolan cement per job. Although the squeeze jobs were scattered and the horizons treated varied, making it difficult for a comparison with neat cement, it is believed the 158 sack average is approximately 30-40 sacks less than that required for neat cement.

A 50 per cent pozzolan-50 per cent cement, 5 per cent bentonite and 1 per cent lost circulation material (cellophane flakes) has proved successful in combatting lost circulation or cementing a string of pipe in areas of known lost circulation zones.

Excellent results have been obtained in selectively acidizing closely spaced thin horizons without communication. It is difficult to determine if the resilience factor, lower heat of hydration, or combination of conditions is responsible for the favorable results of this type of completion.

It must be realized that the use of a pozzolan cement slurry in lieu of slurries of other materials, does not alter the basic technique of obtaining a good cementing job. Essentially, a good mud program combined with the use of two plugs and other recognized tools such as centralizers, wall cleaners and special applicable devices are necessary for a satisfactory cementing job whether pozzolan cement or cement is used.

It is anticipated that future availability of pozzolan cement will include the entire oil and gas producing sections in the United States. This statement is based upon the inexhaustible supply of pozzolans throughout the country.[7]

The correlation of results by laboratory tests and field applications of the new cement has been satisfactory and gratifying. These results have opened an avenue of great possibilities for the future development of blending cementitious materials to obtain optimum results for cementing wells.

Summary

The survey of literature, results of laboratory tests, and field applications of mixtures of pozzolanic materials and cement for oil well cementing indicate this type cementing material has the following advantages:

1. The water ratios are such that a large portion of the slurry volume is solid cementitious material. It is necessary with some oil well cementing additives to use large quantities of water in order to obtain pumpable slurries with satisfactory properties.
2. When pozzolanic materials are blended with portland cement and a slurry is prepared, the pozzolan itself is reactive with certain undesirable compounds of the cement and is not merely an inert filler.
3. The slurry weights are somewhat lower than with neat cement and can be changed by varying the amount of pozzolan used.
4. A cement resistent to corrosive sulfate and weakly acid brines can be easily prepared with readily available commercial cements.
5. Less soluble reaction compounds are formed during cement hydration. Thus, the set cement is less subject to the leaching action of water and brines and maintains less permeability over a longer period of time.
6. Lower early strengths allow for better gun perforating with less shattering of the cement and greater penetration due to less resistence to the force of the perforator.
7. The heat generated by the hydration of pozzolan cements is less than the heat generated by an equal volume of a neat portland cement slurry.

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Acknowledgment

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* * *

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Now officially classified as a YF Tender Barge, the oil well machinery filled ship is on its way to Venezuela for drilling operations in the Pedernales Area in eastern Venezuela on the Gulf of Paria.

Stationary equipment of the YF consists of a compound[1] with four diesel engines[2] powering two pumps,[3] generators, and utility units. A mud-mixing pump[4] powered by an engine[5] with a hydraulic governor is also part of the stationary equipment.

Also aboard is a rig[6] drive with two engines[2] one drawworks[7] and the other necessary equipment to make a complete drilling barge. This equipment will be transferred to the drilling barge when the YF reaches its Venezuela destination.

All dimensions and specifications covering the machinery were supplied the California Company's designing and engineering department by the New Orleans office of Mid-Continent Cummins Export Corporation under the direction of district manager, W. M. "Pete" Day. W. L. Lansing, field engineer, R. V. Cross, construction engineer, both of the California Company, and Ken Chaffin, tool-pusher, and Thornton Tarvin, New Orleans representative, both of Loffland Brothers Company, were responsi-

†Mid-Continent News.

[1]Mid-Continent 6240.
[2]LRI Cummins.
[3]D-500 EMSCO.
[4]D-175 EMSCO.
[5]NHP Cummins.
[6]Mid-Continent 3120 rig.
[7]U-15.

At top of page, a former Navy supply ship, the 205-ft craft has been converted into a YF Tender Barge to be used in South American drilling operations. Inset was taken from top deck of barge looking aft as crew was securing hatch covers. Just above, another view of the top deck ship-shape for sailing.

Shown here is the Mid-Continent-Cummins 4-engine compound, powered by 4 LRI Cummins diesels. This unit powers the 2 Emsco D-500 pumps shown in the background. It also powers a smaller pump which is connected to the belt drive shown in the foreground. The installation is unusual in that the drive supplies power to the input of the drawworks, in this case drives the small pump.

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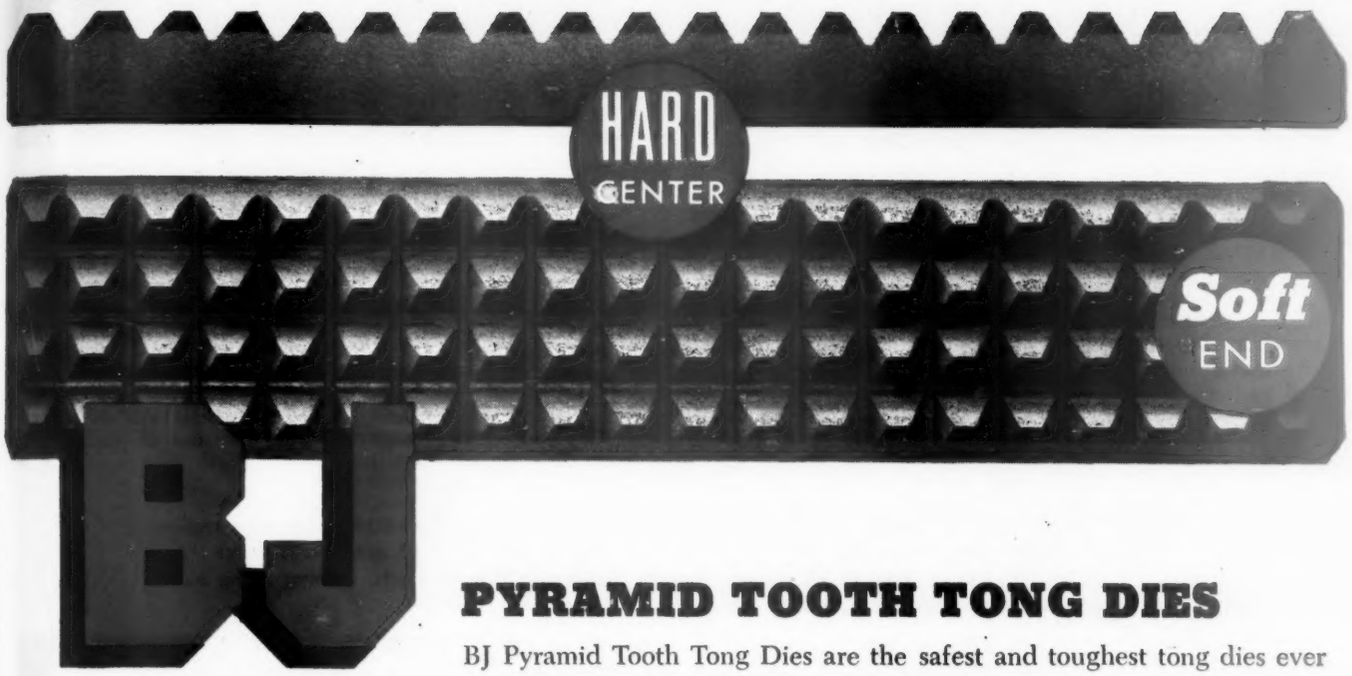

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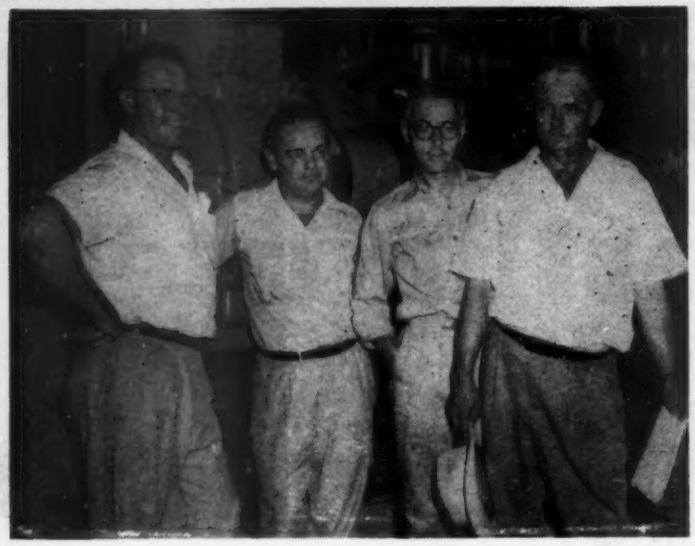


Responsible for conversion are K. E. Chaffin, toolpusher of Loffland Brothers; R. C. Cross and W. L. Lancing, California Company engineers, and H. A. Mitchell, superintendent of Haggard Welding and Machine Works.

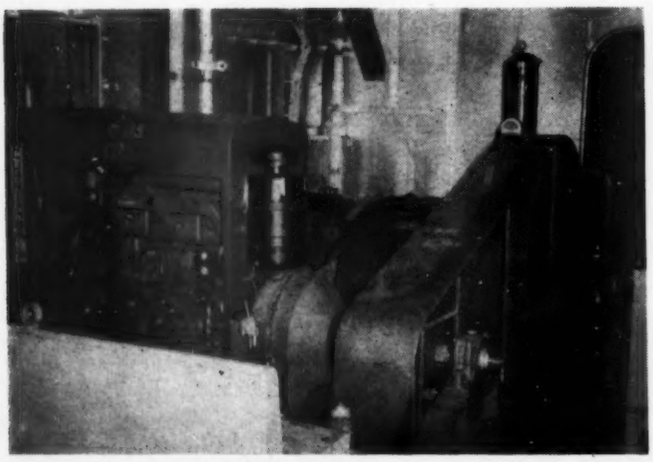
Here is shown one of the Emsco D-500 pumps powered by LRI Cummins engines.

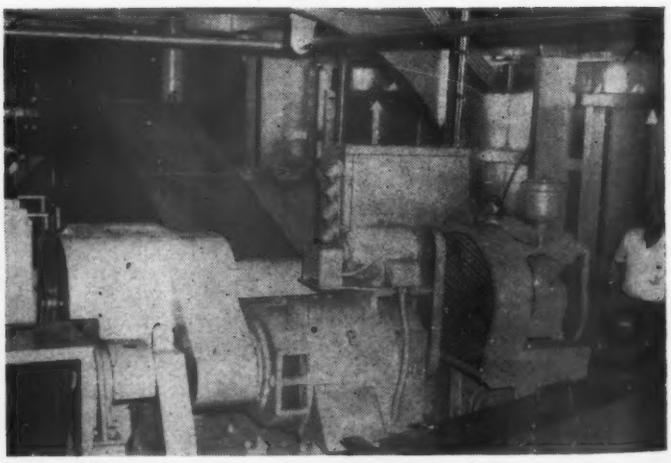
ble for the setting of the machinery aboard this barge.

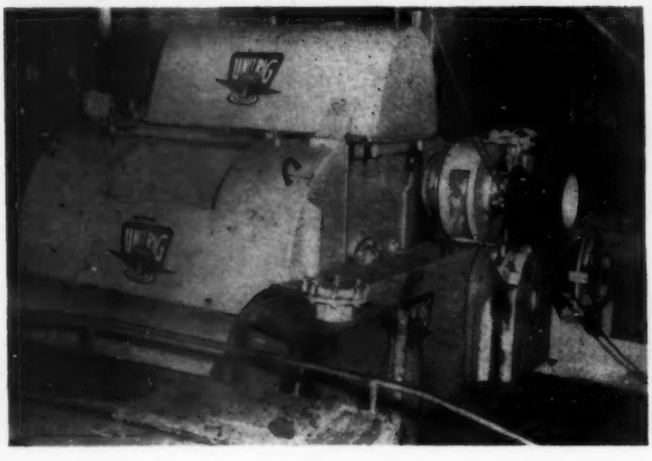
All major machinery items were supplied by the Fort Worth machinery department of Mid-Continent Cummins Export Corporation, and the balance of materials needed to complete the outfitting were supplied by Mid-Continent Supply Company's stores at Houma, Lake Charles, and New Iberia, Louisiana, and Houston, Texas.

Complete supervision of the job's materials was maintained by Pete Day and Shellie Waites of the New Orleans office. Waites was assigned the job of Materials Co-ordinator and had all materials on hand by the time they were needed for installation. Complete time on the installation job from start of work to time of sailing was 59 days. * * *

Another view of the installation, top left below, shows an Emsco D-175 pump powered by an NHP Cummins engine. Top right below shows the Thyrite Generating Unit while at the bottom left is a Unit Rig U-15 drawworks which will be transferred to the drilling barge when the tender reaches its destination. The mud pits, running along both sides of the barge amidships are pictured in the lower right corner.







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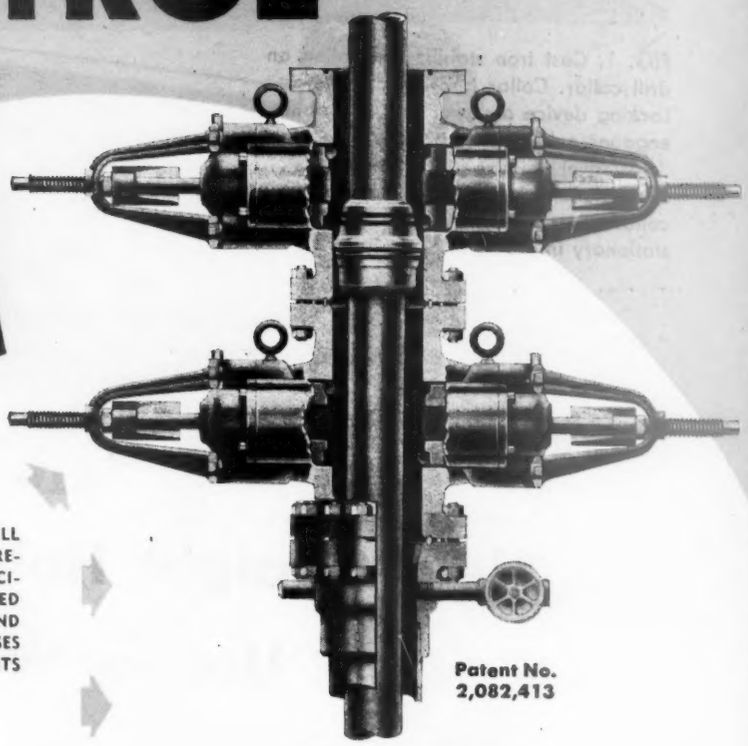
The whole is greater than its individual parts. An oil well is built into the ground through a series of related operations. Well Control is the study of such procedure; and a particular type casing hanger or tubing hanger cannot solve a well control problem, as they are only parts of the whole.



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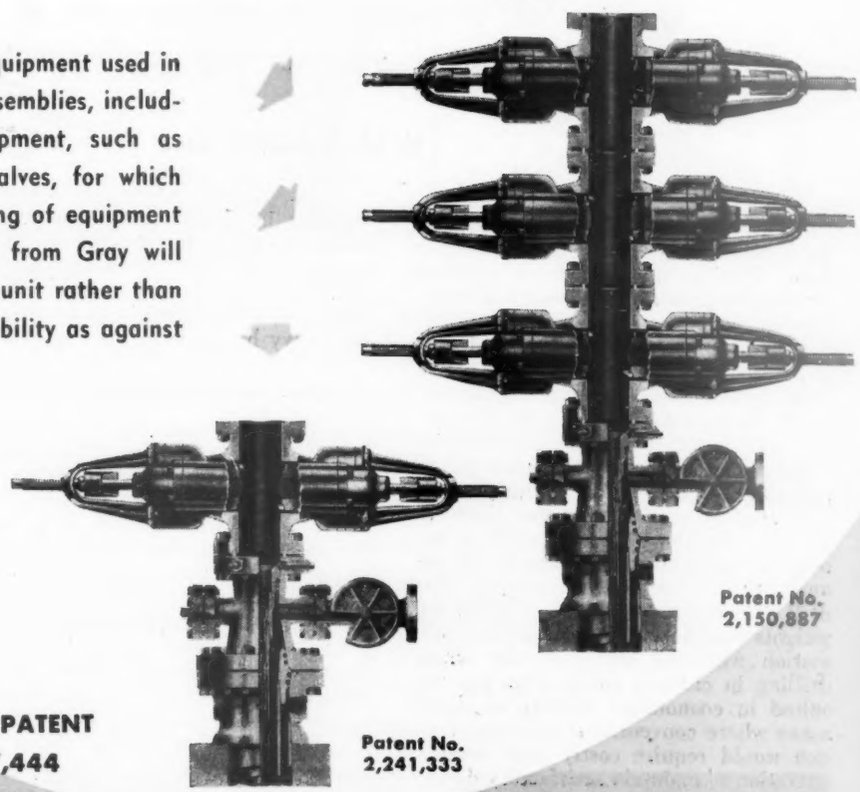

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FIG. 1. Cast iron stabilizer installed on drill collar. Collar turns inside sleeve. Locking device at lower end of stabilizer engages only if it is necessary to "wash-over" sleeve. It is disengaged under normal right hand rotation of drill collar allowing stabilizer to remain stationary in the hole.

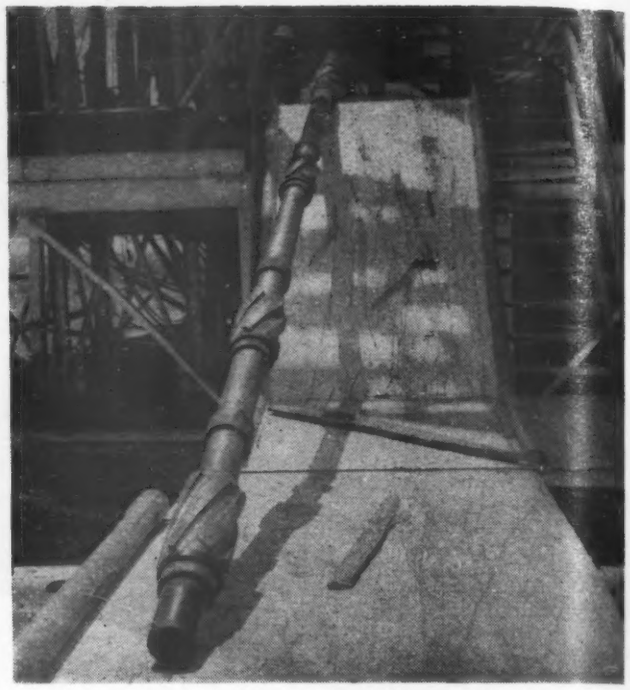

FIG. 2. Bottom drill collar stabilizer assembly complete with four cast iron stabilizers installed.

EXCLUSIVE

New Straight Hole Drilling Tools in Use in West Texas

Greater rate of penetration and reduction of rapid deviation charges were obtained in crooked hole country with drill collar stabilizers

H. M. ROLLINS and W. S. BACHMAN

IN RECENT months in crooked hole areas of West Texas, a new type "straight hole" drilling tool has shown unusual promise in preventing excessive hole deviation. This new tool, known as a bottom drill collar stabilizer (Figs. 1 and 2), is a conventional bottom drill collar utilizing cast iron sleeve type stabilizers, which do not rotate in the hole. The stabilizers are installed at selected intervals from the lower end to the upper end of the collar. Because the stabilizers are only slightly smaller than the diameter of the hole, the stabilized drill collar tends to resist lateral drifting of the bit and helps to prevent bending of the drill stem just above the bit. Heavier bit weights may be safely used in hard formation with this stiffer section when drilling in crooked zones. This has resulted in economical drilling of these zones where conventional drilling practice would require costly light weight operation to maintain satisfactory deviation.

Although crooked holes have been a problem in a number of areas since the advent of rotary drilling, the problem has not been particularly troublesome in West Texas until recent years. The reasons for the increase in crooked hole troubles in West Texas appear to be associated with the changes in drilling practice that occurred in the 1944-1946 period. In this period the use of long strings of drill collars, with accompanying heavy bit weights, became common procedure in the Permian Basin. This heavy weight program, together with newly developed hard formation rock bits, helped to lower drilling costs and accelerated deeper drilling programs into the Devonian and Ellenburger sec-

The Authors

Henry M. Rollins is an engineer with the newly formed Drilco Engineering Company of Midland, Texas. A graduate of Texas A. & M., Rollins joined Hughes Tool Company in 1947, as a project engineer in the Hughes engineering laboratories, observing field tests of experimental products. He was assistant product engineer for tool joints and drill collars when he left Hughes in 1951 to join Drill Collar Service Company in Midland as chief engineer, joining Drilco Engineering at the time of its formation.

William S. Bachman is an engineer with Drilco Engineering. Prior to the organization of Drilco, he was an engineer in the research engineering department of Hughes Tool Company for three years, and later Mid-Continent regional engineer for Security Engineering Company for a year. He was graduated from the University of Texas with a degree in mechanical engineering and served in World War II as a Navy radar officer.

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FIG. 3. Going in hole in Wilshire-Ellenburger field in West Texas with drill collar stabilizer.

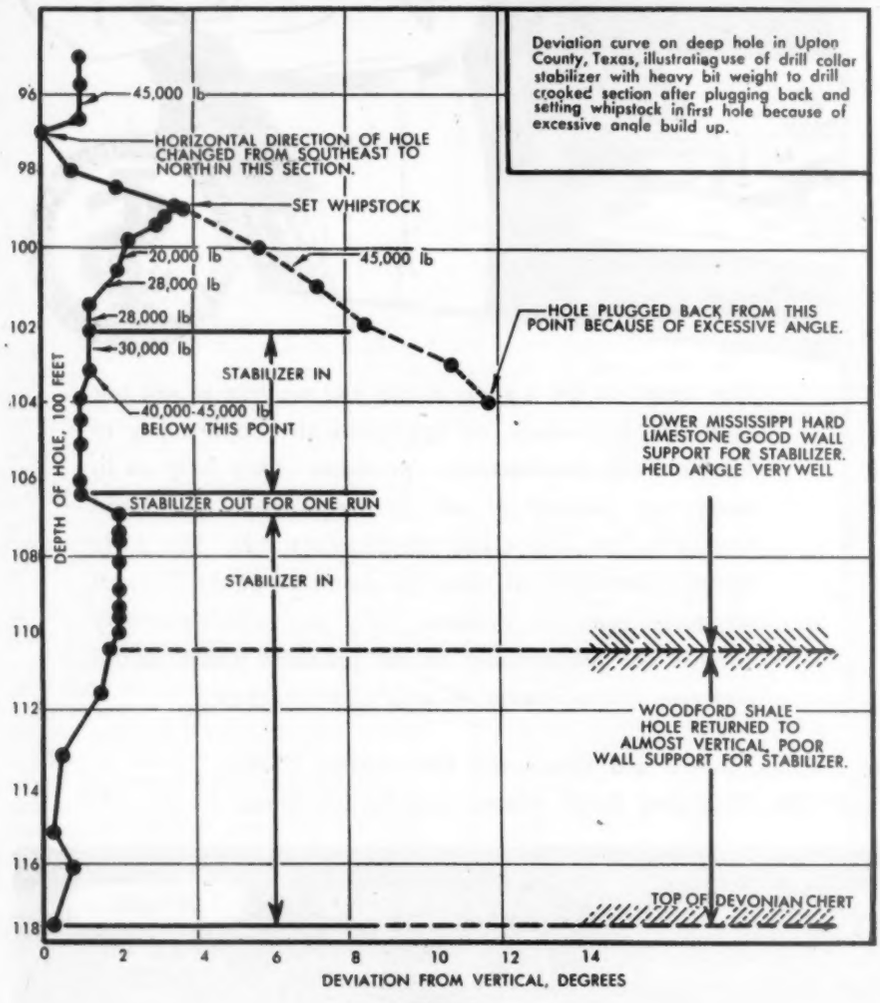


FIG. 4.

tions, opening many new fields in these deeper formations. Unfortunately, associated with this deeper drilling were many of the factors that contribute to crooked holes, such as steeply dipping structures, striated hard and soft formations, nodular chert, and generally harder rocks which required heavy bit weight for economical drilling. This heavy weight results in buckling of the drill collar string, a condition also believed to contribute to drilling crooked.

The time honored method of using high rotary speed and light weight for drilling straight holes in crooked sections and for straightening crooked holes is extremely costly and slow in these high strength, abrasive formations. Because of this high cost, a number of West Texas operators have attempted to devise tools and methods for keeping holes straight when drilling through known crooked hole zones.

Large diameter drill collars—8 in. O.D. collars in 8¾ in. hole—have been used at the bottom of the drill collar string by some operators. This has had the effect of reducing the buckling effect of the drill stem immediately above the bit. This practice has helped prevent rapid changes in angle of the hole; however, the use of large collars has not become general because of the inherent danger of running collars that cannot be "washed-over" in event they become stuck in the hole.

One of the early advocates of the large diameter drill collars went one step further toward a solution of the problem. In addition to running 8 in. OD drill collars in 8¾ in. hole, this contractor welded longitudinal ribs to a short bottom drill collar to bring the collar diameter to 8⅝ in., thus giving the bit support to resist lateral drift as well as to minimize bending of the drill stem. This tool has performed well, but has not been widely used because of the difficulty of fishing for such a drill collar.

In more general use than the large diameter collars are three point reamers placed in the string as stabilizers. These reamers, when run as stabilizers, are usually equipped with smooth rollers. The location of the string reamers has generally been 30 or 60 ft above the bit although in the past few months other spacing has been tried in conformance with the recently published theoretical data on drill collar buckling. The intention in running the string reamers has been to prevent bending of the drill collars and to center the string in the hole. Some operators consider the string reamer acts as a pivot point to improve the straightening characteristics of the lower drill collars. There have been reported encouraging results in some areas; however, no general procedure has yet been developed.

The latest additions to the "straight

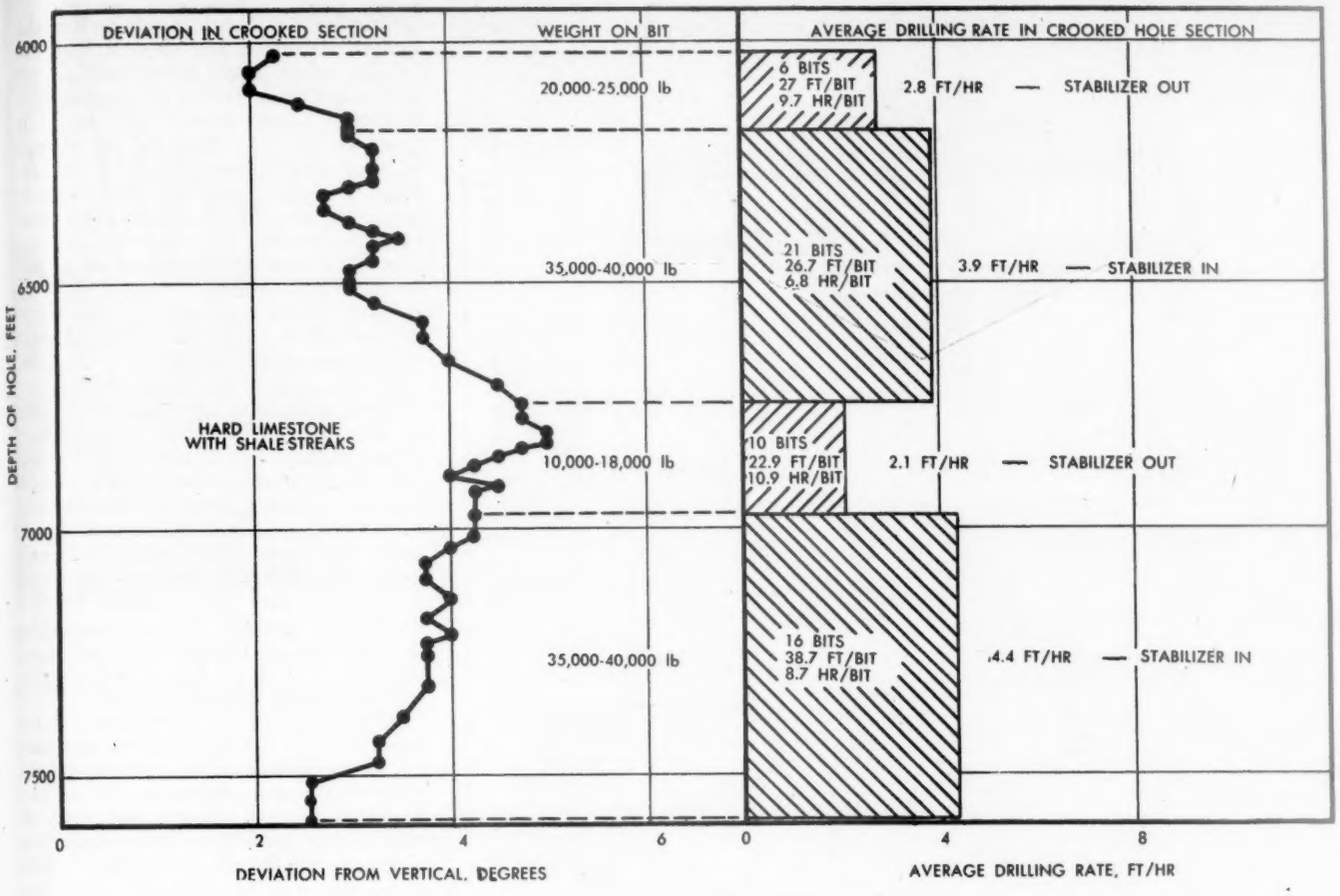


FIG. 5. Drilling record of well in Upton County, Texas, illustrating increase in rate of penetration when running heavy weight and using drill collar stabilizer in crooked sections to prevent rapid change of angle.

hole" drilling tools have been the cast iron and rubber sleeve type stabilizers. Various types of rubber sleeves are being field tested and data should soon be available to evaluate their efficiency.

Results of a number of field runs are now available for the cast iron sleeve type drill collar stabilizer, and this information indicates that where there is sufficient wall support, rapid changes in angle can be prevented even when drilling with heavy weight.

As shown in Fig. 1, the stabilizing device consists of cast iron stabilizers, which, when placed on the drill collar, form plain journal bearing guide bushings for the bottom drill collar, holding the collar in the center of the hole, stiffening it, and aligning it with the hole that has been drilled. Normally, four of these stabilizer sleeves are used on the bottom drill collar (Fig. 2), and quite frequently one is used on a sub at the joint approximately 60 ft above the bit. The collar rotates freely inside the stabilizer sleeve. Axial travel of the stabilizer is restricted by retainer rings that are held in place on the collar by a shrink fit.

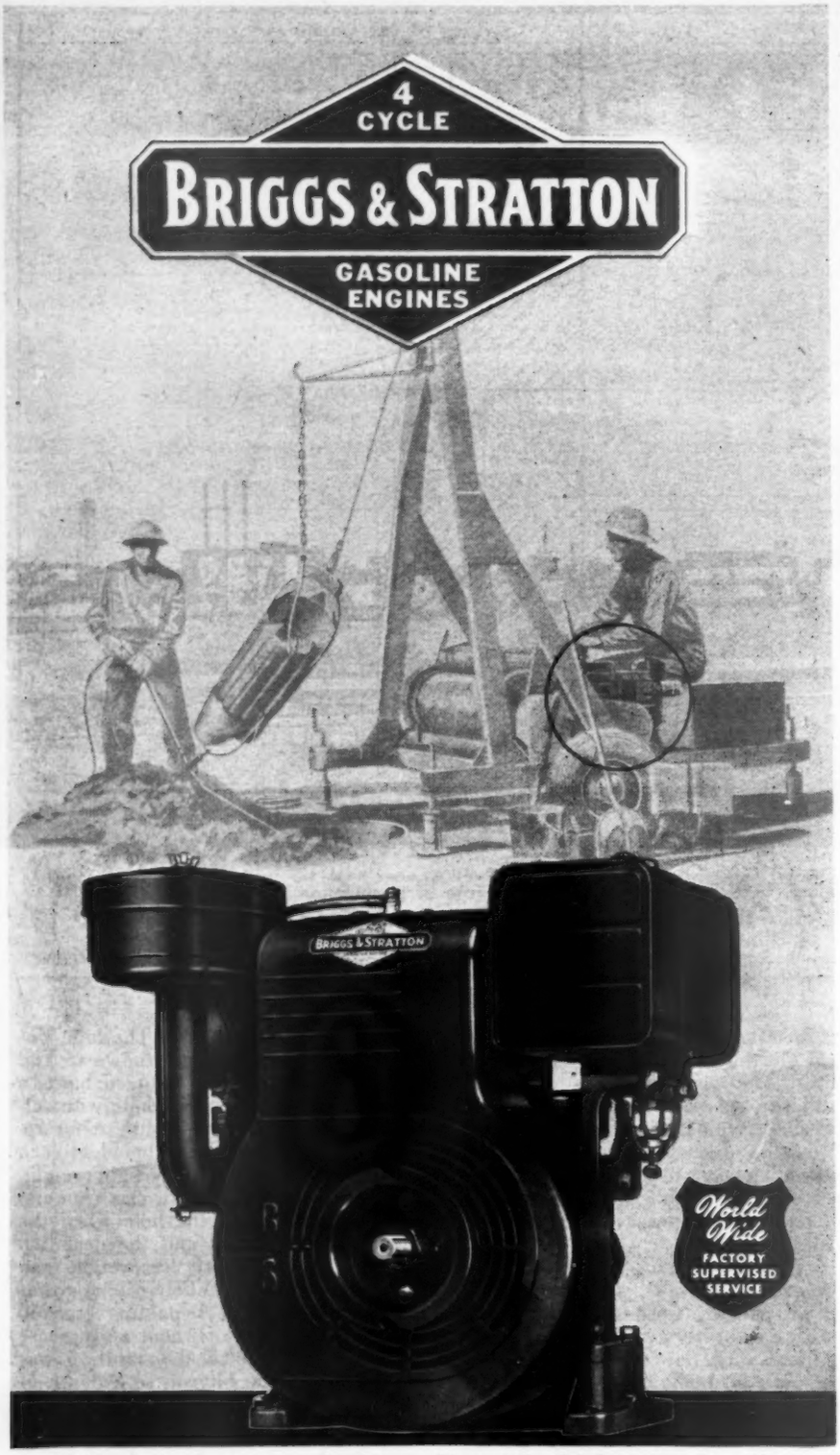
The lower end of the stabilizer sleeve and the upper face of the bottom retainer ring comprise mating members of a ratchet clutch. In the event it becomes necessary to "wash-over" the stabilizer, the washpipe rotary shoe will rotate the stabilizer sleeve until the clutch engages, and then the stabilizer will be stationary while the rotary shoe mills off the stabilizer. The cast iron from which the stabilizers are made is easily drilled up. The steel retainer rings are made with an outside diameter smaller than the inside diameter of washpipe commonly used in a given hole size. Therefore it would not be necessary to mill-up the steel rings.

To date this tool has been used in approximately 30 wells, and no operator has yet had to "wash-over" the stabilizer. The stabilizers are machined 1/8 in. smaller on outside diameter than the size of the bit being used, and normally the tool is run in and out of the hole freely. It is usually advisable to run a reamer between the stabilizer and the bit to insure a full gage hole.

The bottom drill collar used with these stabilizers must be machined to a specified diameter within close tolerances in order to provide the proper shrink fit of the retainer rings. This can be accomplished in most field machine shops.

An interesting example of the use of the stabilized bottom collar is illustrated by a hole drilled on the south edge of the Pegasus field in Upton County, Texas, Fig. 4. While drilling 8¾ in. hole with conventional practice of 45,000 lb bit weight at 60 rpm, the operator encountered an increase of vertical deviation of the hole from 1 deg at 9600 ft to 11 deg at 10,400 ft. The hole was surveyed with the results shown in Fig. 4. This first hole was plugged back, a whipstock set, and a new hole with satisfactory deviation was begun. After approximately 240 ft of new hole had been drilled with comparatively light weight, a bottom drill collar with cast iron stabilizers was run in the hole when the depth was 10,218 ft and the deviation 1¼ deg. Using slightly less weight than that used on the first hole, the operator drilled through the remaining crooked zone a second time without an increase in angle. At 10,638 ft the stabilizer was not used for one bit run to a depth of 10,687 ft. During this interval of 49 ft, the vertical angle increased from 1 to 2 deg. After the stabilizer was again added to the drill stem, the hole was drilled in hard lime to the top of the Woodford shale without appreciable change in deviation. In the shale, which affords little wall support for the tool, the hole gradually drifted back from 2 to ¼ deg.

This example is useful in evaluating the performance of the tool because the first hole drilled indicated that a crooked hole condition existed between 9700 and 10,400 ft. The fact that the hole went off 1 deg in 49 ft at a depth of 10,639 ft when the stabilizer was not in the hole for one trip would indicate that for the weight being used, crooked hole tendencies of the formation continued through most of the limestone section.



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The stabilizer held the angle well in the harder formation but showed less stabilizing effect in the softer shale.

The deviation record of another hole in Upton County near Crane, Texas, is given in Fig. 5 to illustrate the savings made by one operator in using the stabilizer through a relatively thick crooked zone. At the time consideration was given to running the stabilizer, the operator's bits were averaging 2.8 ft per hour while running 20,000-25,000 lb weight. Even at this weight the hole had drifted off to 3 deg. A stabilized drill collar was placed at the bottom of the drill stem and weight on the bit was increased to 35,000-40,000 lb for the next 21 bits. The drilling rate increased to an average of 3.9 ft per hour. During the 550 ft interval, where heavy weight was run, the angle slowly increased from 3 to 4¾ deg. Ten bits were then run using light weight and the hole returned to 4¼ deg. The stabilizer was again run in the hole and after running 16 bits under heavy weight, the hole was at 2½ deg inclination. During the running of the last 6 of these bits, the hole was drifting slowly toward vertical.

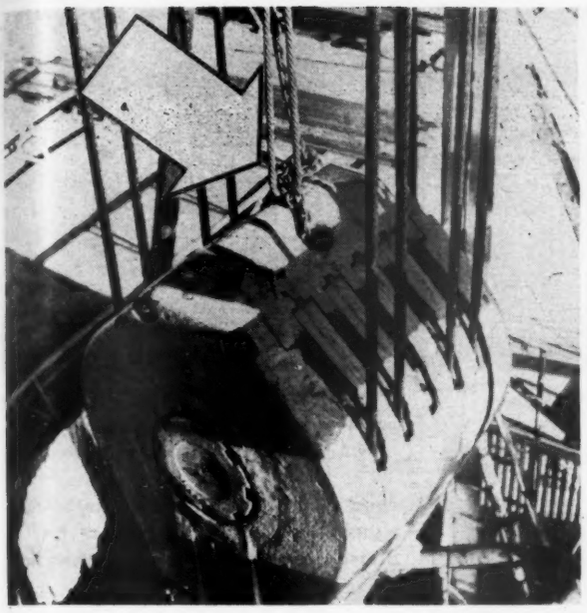
As this hole was a wildcat location, no offset records are available to indicate the exact thickness of the crooked hole zone. From the characteristics of the deviation curve, it appears that much of that section drilled while the stabilizer was used tended to be crooked. While using the stabilizer, 37 bits were run under heavy weight and only 10 bits under light weight. Those bits drilling under 35,000-40,000 lb had almost twice the rate of penetration of those bits used under 20,000-25,000 lb. It is believed that the operator was able to run more bits under heavy weight while maintaining a satisfactory angle because the stabilized collar was used.

The two examples presented indicate the tool has been an aid, but certainly no absolute remedy for crooked hole. These data are encouraging principally because they are typical of the results obtained from several other wells on which the stabilizer has retarded vertical drift. Additional experience, development of techniques, and analysis of a greater number of holes will be required to fully evaluate this new tool. * * *

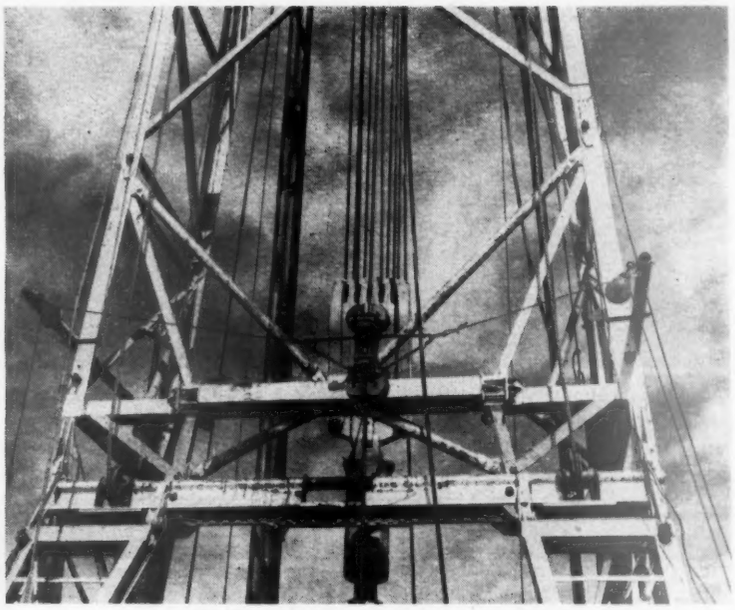
General American to Head Search for Oil in Spain

General American Oil Company of Texas has reported that it will head a group of approximately 12 American companies and individuals looking for oil in Spain in a joint-venture arrangement with the Spanish government.

The group, which includes DeGoyler and MacNaughton, Dallas, Texas, geological firm, and Delta Drilling Company, has put up some $1,000,000 to search for oil in the Ebro River basin in northern Spain. A like amount will be put up by the Spanish government. Profits resulting from the search will be shared on a 50-50 basis. The first geological crew is scheduled to be on the ground by January 1, 1953.



Suspending travelling block, hook, and elevator on a 1-in. hang line, or larger to make ready for drum end cut. Laying blocks on derrick floor is unnecessary.



Wire line stabilizer positioned to counteract a bad fleet angle. Stabilizer is controlled by weight buckets suspended under the derrick floor where the weight can be conveniently regulated.

Has Your Drilling Rig Got a Groove In?

Wire rope costs in drilling can be reduced by installing a special system — Tedious spooling problems are now solved

JACK MENNEER*

MANY on reading the title of this article may think that a printer's error has occurred, and that it should read, "Has Your Rig Got In a Groove?" The solution to your quandary is more complex than ever and it is thus: If your rig hasn't got a groove in, it is in a groove!

Lebus International Engineers[1] appropriately held a meeting at their plant in Longview, Texas on September 5 and 6. A long view of the problem could be taken. Believe it or not the result was: To get your rig out of a groove, you have to put a groove in!

Engineers had gathered at Longview from places as far apart as Canada and Venezuela in order to evaluate the merits of a good wire spooling practice for a drilling rig.

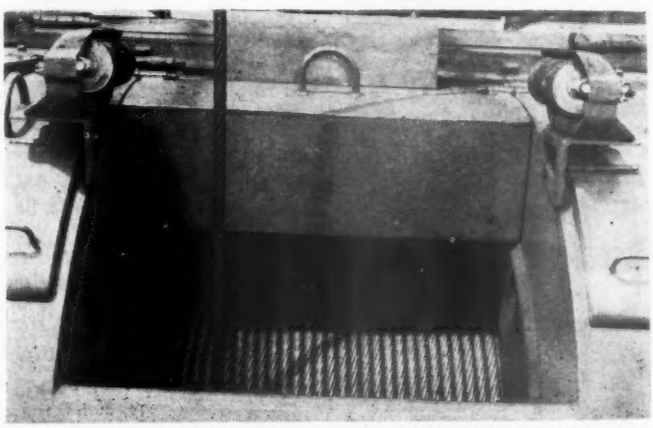
In the past little attention has been given to the mechanics of spooling wire ropes for usage on drawworks. Without doubt considerable wastage occurs annually due to an inefficient wire line installation, to say nothing of the time taken to spool after each cut-off or, for readjustments or, for new line requirements.

The matter has now been tackled, however, on sound engineering principles together with simplicity, rapidity of handling, an increased rope life, and a reduction in down-time. These mean a saving in operational costs. Instead of allowing drilling lines to be operated inefficiently and more expensively than is necessary, a patented method is now available for spooling effectively.

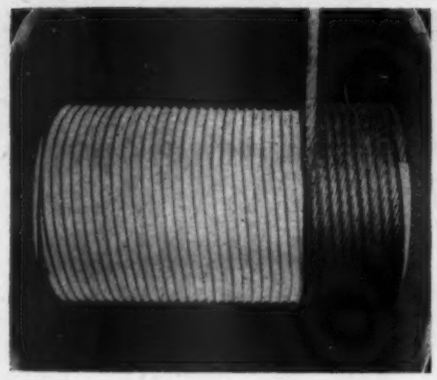
Some may think all that is required in hoisting operations is to have a good wire rope that will give long and rugged service. Or that as long as the traveling block moves up and down the derrick and the wire wraps itself around the drum in an apparently satisfactory

*Editor Drilling and Producing.

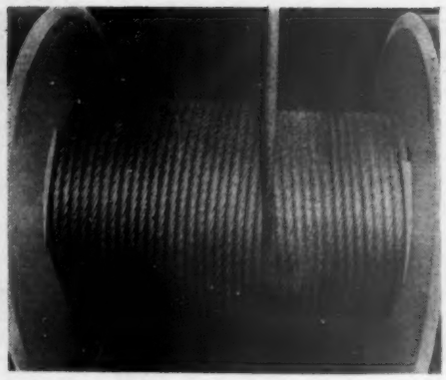
[1]Specialists in The Lebus Grooving and Controlled Pyramid Spooling System for wire line ropes in the oil industry.



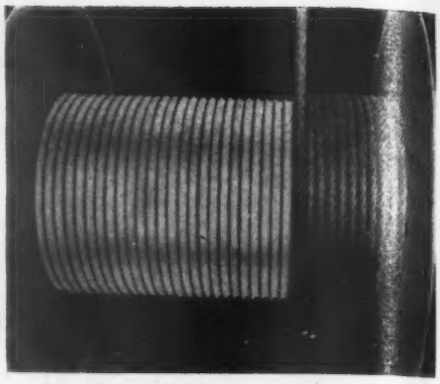
Rollers are so placed on drum guards to help kick line back for correct cross-over on successive wraps. Without these rollers line will pile against drum flanges when a bad fleet angle exists.



Angle control section of LeBus grooved drum illustrating load being picked up with 10 to 15 wraps of line on the drum. This requires from 100 to 250 ft less line in spooling system.



Second layer of wraps (center) crossing over within same limited area of angle control sections. Double cross-over wave causing excess wire line slip between crown block and drum is eliminated.



Third photo is first layer of line being wrapped on parallel section of the drum. The result is a smooth running line.

manner, then all is well and nothing else can be done for improving conditions.

Better wire rope operating conditions, however, can be obtained by incorporating a special and controlled pyramid spooling system.[2]

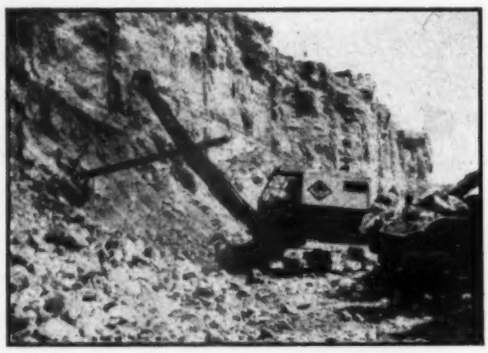
The method necessitates the welding of prefabricated grooves on to the plain drum core to form a pattern of parallel and angle control sections. The parallel covers from 75 to 85 per cent of the circumference of the drum core. The load can be picked up with only 10 to 15 wraps of line on the drum, and in consequence a 100 to 250 ft less wire line is required in the spooling system. Progressive grooving is obtained and the old problems of cutting-in, crowding-over and whip are eliminated.

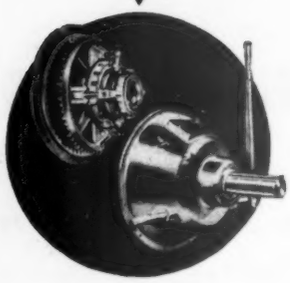
It is important that the fleet angles be kept to within small limits, about 1½ deg. Also, stabilizers should function with correct weight and height. Turn back rollers assist in maintaining the correct cross-over on successive wraps, particularly in a jack-knife derrick where the fleet angle may be excessive. The weight of the travelling block, attendant hook, and elevators is closely related to good spooling when running unloaded so as to avoid any cutting-in when running back into the hole with drill pipe. The combined weight of these items (block, hook, and elevators) should be at least 8000 lb for a well down to 7500 ft where six 1 in. or 1⅛ in. wire lines are used, or 12,000 lb for 8 lines. A 12,000 to 14,000-ft well with 1⅛ in. or 1¼ in. wire would require a combined weight of 15,000 to 20,000 lb. For depths greater than 15,000 ft and a 1¼-in., 1⅜-in. or a 1½-in. line the combined weight should be from 20,000 to 30,000 lb.

Spooling operations of the controlled pyramid system is less time consuming than in the plain drum type because the wire will be automatically wrapped. A groove installation will probably pay for itself while wearing out 5000 ft of line under usual routine drilling. In other words, and contrary to philosophical advice, it pays to get in a groove! ★★

[2]Lebus patent.

Takes Big Bites Of Granite





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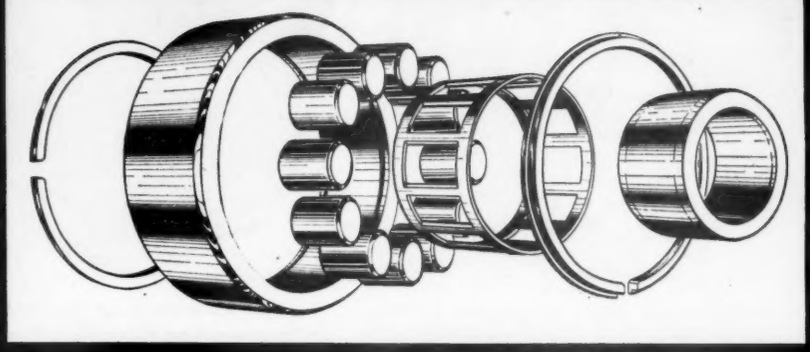

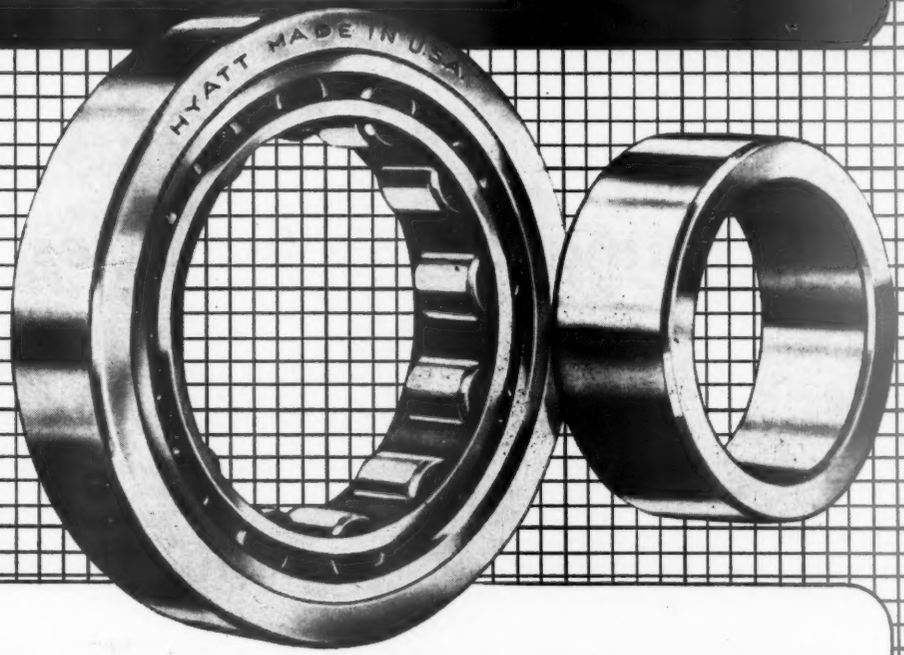

IN THE family of Hyatt Hy-Load Roller Bearings is the popular A-TS type, one of the separable inner race, high-capacity cylindrical roller bearings made in two diameter series, wide and narrow widths, to standard boundary dimensions.

Separable parts are freely interchangeable. Any inner race will fit any roller assembly of the same piece number, permitting non-selective fitting after preassembling the two bearing parts in separable machine elements.

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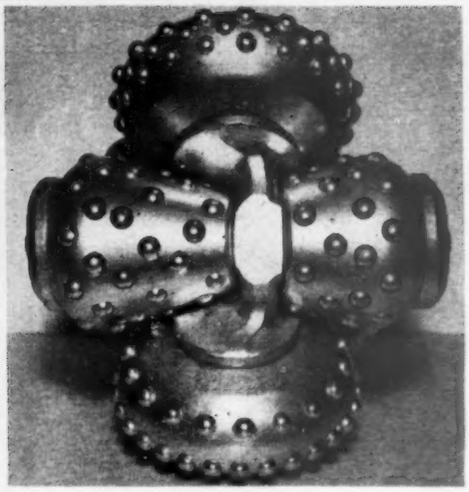
A straight cylindrical inner race permits lateral expansion of the shaft through the bearing in applications where this is an important consideration.

May be applied with the rollers operating directly upon the shaft to utilize larger shaft diameter or bearing of smaller size, thereby gaining greater shaft rigidity.

For full information about the "A-TS" and other Hyatt Hy-Load Roller Bearings, write for Hyatt Catalog 547. Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.

HYATT ROLLER BEARINGS

This view of "Cobra" bit shows its general design. Notice "Twin-Blast" slush nozzle that directs mud circulation to bottom of the hole.



This bottom view shows the tungsten carbide inserts on the cutters. These inserts have been carefully placed to insure uniform wear of the cutting elements.

This view of a worn bit shows the uniform wear on the cutters. It is easy to see why drilling rates remain uniform throughout the life of the bit.

Hard Formation Bit Increases Penetration

More economical drilling in a particular type zone is evidenced — Advanced technique may make exploration of previously considered "impossible areas" possible

E. A. BOICE*

A CRUSH-TYPE hard formation bit has been developed.† In extensive field tests this bit consistently gave from four to eight times the footage of conventional bits when drilling extremely hard and brittle formations.

Before going further it must be emphasized that it is a special purpose bit in the strictest sense of the word. It was designed for very brittle formations with a high compressive strength. It is not a cure-all!

Conventional rock bits will, generally speaking, drill a wide range of formations satisfactorily but current field experience with the new type bit has shown that, as the formation becomes softer, rate of penetration drops off rapidly. In broken formations the bit has a tendency to run "rough."

Basically, the bit uses the same bearings and cross roller design as other hard formation bits manufactured by this company. Instead of conventional teeth on the cutters, however, it has a series of tungsten carbide inserts imbedded in smooth rollers. The contact surfaces of these inserts are spherical in shape, which gives the bit an unconventional appearance.

The bit is as unconventional in performance as it is in appearance. This fact becomes readily apparent when one considers these conclusions that have been derived from experience gained in extensive field tests:

Footage per Bit. In West Texas chert formations (30 per cent chert content or better) the bit was found to drill from four to eight times the footage of conventional hard formation bits. In laboratory tests on still harder formations such as pink quartzite (compressive strength from 50,000 to 60,000 psi) it was found that the bit would drill 15 to 20 times as much footage as conventional bits.

Rate of Penetration was about three to four feet per hour in West Texas chert formations with the drilling rate falling off in softer formations.

The rate of penetration, in the same formation, remains substantially constant throughout the life of the bit. As rate of penetration does not fall off with bit wear, some form of torque indicator is needed to tell when the cutter bearings are becoming worn. It should be pulled whenever the torque rises appreciably.

Drilling Weights and RPM. Field experience with bits in the 8¾-in. size range indicates that weights of 25,000 to 35,000 lb are adequate. This is somewhat less than the weights required for conventional bits.

Relatively slow rotary speeds of 30 to 50 rpm seem to give best results. It is believed that slow rotary speeds give the fluid time to clean the bottom of the hole, thus avoiding re-cycling of cuttings.

Circulation Requirements. Best results and longest runs have resulted when bottom hole circulation, such as that obtained with "Twin-Blast" slush nozzles, is used.

In this connection it is important to pump enough fluid to maintain the high nozzle and return annulus velocities required to keep the bottom of the hole free from cuttings.

Geological Considerations. Tests have indicated that penetration characteristics of this bit are the reverse of those found when running conventional bits; that is—the harder the formation, the faster it drills.

Unless a geologist is warned, he may erroneously conclude that the bit is striking a softer formation when actually

*Director of research, Reed Roller Bit Company.

†Known as the "Cobra," Reed Roller Bit Company.

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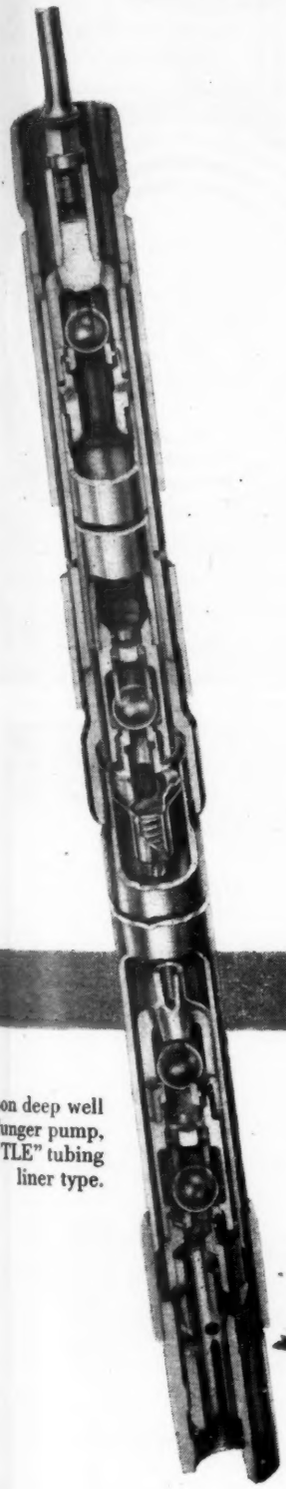

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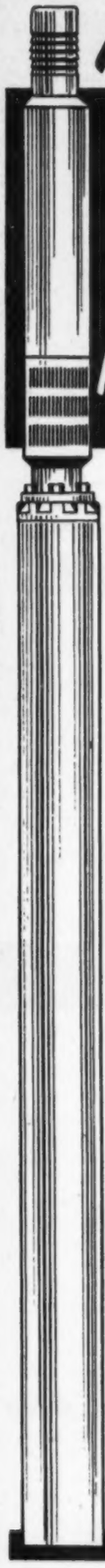

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Reda engineers have long been associated with water flooding operations and are fully qualified to assist operators in discussing their source water requirements.

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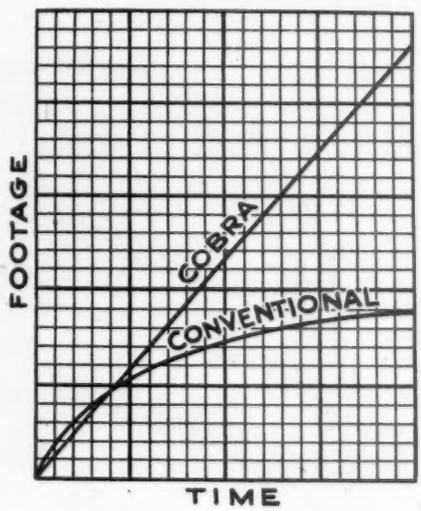
View of "Cobra" bit running on laboratory drilling machine, drilling in granite.



Graph shows difference in drilling characteristics of "Cobra" bit compared to conventional hard formation bits.

it has encountered a harder, more brittle one.

Economic Considerations. It is too early to draw any firm conclusion regarding the economics of running these bits but tests indicate that where thick streaks of hard, brittle formation are encountered, there is a substantial economy in round trips and drilling time. It is believed that bit costs per foot will be comparable to conventional bits in spite of the high first cost of the bit, as each bit gives so much more footage. Many round trips and much rig time are saved, thus effecting an overall economy in drilling costs when using the bit.

It is impossible to foresee what the development of the bit will eventually mean to the drilling industry, but it is evident that a means has been provided for more economical penetration of known hard formations. The bit may also make possible the exploration and production of pay zones heretofore considered uneconomical to develop. ★ ★

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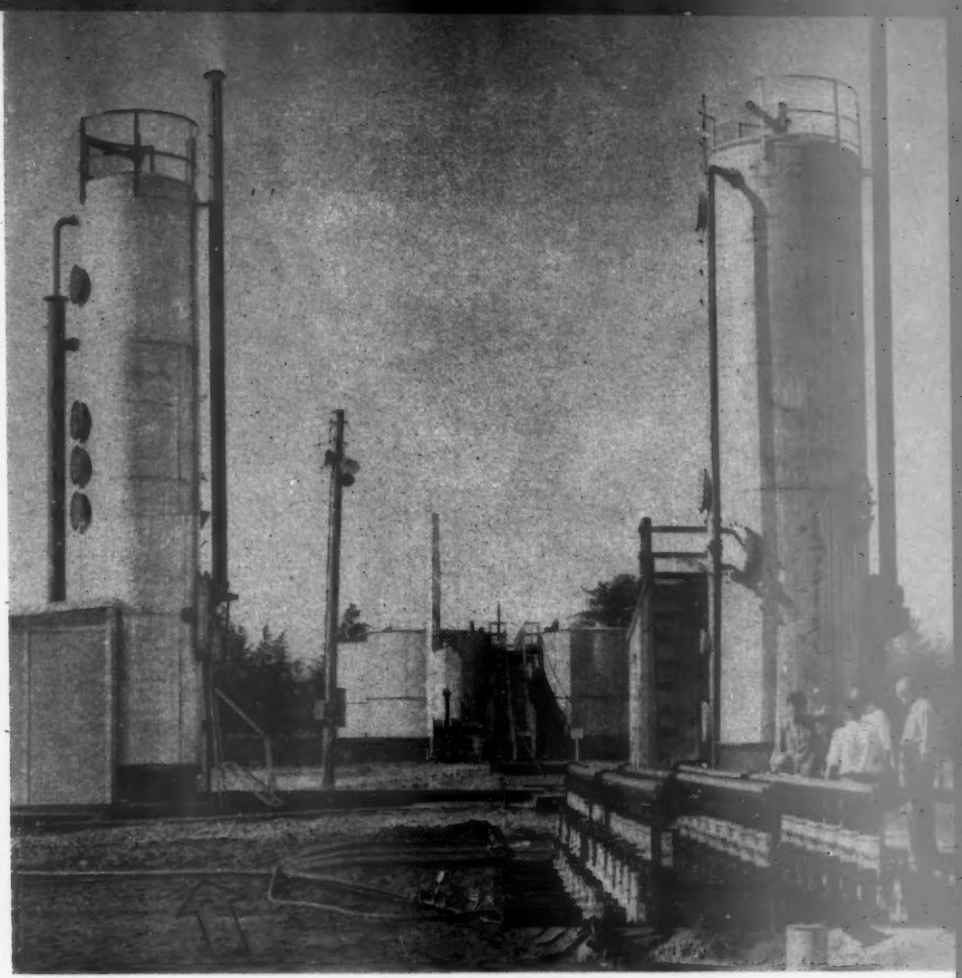
Pipefitters join two Tenite pipe lengths together. Except at one road crossing, where the pipe is buried line runs entirely on surface.



The 2-in. IPS Tenite butyrate plastic pipe line in left foreground brings crude oil to the battery from a pumping well 3300 ft away under constant 30 psi. Tenite Pipe installation is in Redwater oil fields, Alberta, Canada.

P 542.

Plastic Pipe Invades Oil Fields

Paraffin deposition is overcome; soúr crude and salt water can be piped without corrosion tendencies; installation is rapid

SUPERIOR Oil Company recently laid more than 4000 ft of transparent pipe* in the Rio Bravo field, California, which serves as a main water line in the offices and company houses.

The transparent pipe is designed for oil field use, and is made from a plastic. It can be used for flow lines, gathering lines, waste water lines, and domestic water lines, where pressures do not exceed 125 psi and temperatures are atmospheric. It should not be employed where artificial temperatures exist such as hot water lines, etc., but, as the plastic is chemically inert, the pipe will not rust or disintegrate. It is a non-conduc-

*Known as Kraloy and manufactured by Kraloy Plastic Pipe Company and sold by National Supply Company.

EXCLUSIVE

Bob Raab and Dick Kress make joint in Kraloy 2-in. pipe laid for Superior Oil Company.

Tenite butyrate plastic pipe line is shown ready for hookup to well connection. F. W. McEwen of Duplate Canada Ltd., Oshawa, Ontario; Ralph Skinner, president, Canadian Equipment Sales and Service Company, Ltd., Edmonton, Alberta, and N. C. Taylor, Tennessee Eastman Company, Kingsport, Tennessee (left to right), watch Rube Carbol of Canadian Equipment Sales and Service connect the plastic pipe line to the pumping well at the test installation in the Redwater oil fields near Edmonton, Alberta.

California trench made by road grader used for pipe.

tor of electricity and so unaffected by electrolysis.

Plastic pipe is available today in hundreds of various forms, and in sizes from ½-in. through 8-in. The basic type pipe that has been primarily used by the oil industry since 1946 is cellulose acetate butyrate.

Plastic fittings were also used for the Rio Bravo line, including elbow and tee joints.

It is available in 54 different formulations, as well as in a reprocessed form. The 54 types are guaranteed as to tensile, elongation, impact, etc. Reprocessed is available only in black, and carries no guarantee as to its properties.

To protect the pipe from ultra-violet reaction over a period of years, the line should be buried in the ground. It is not affected by an interior buildup from waste water or from paraffin.

Most important, perhaps, in the usage of any plastic pipe is cutting costs. A two-man crew can lay the pipe easily at the rate of 1000 ft per hour, regardless of size, if trenching or backfilling is not needed. Even in trenching a large saving can be made as it is unnecessary to make a flat-bottom trench in which to lay the pipe. Initial outlay on plastic pipe will be high but a reduction in installation maintenance costs will offset such an expenditure.

In Canada plastic pipe* is now in service in the Alberta oil fields of Canada in a surface flow line between oil well and tank battery header. For this test installation the durable plastic piping provides the advantages of light weight combined with exceptional toughness, plus a high resistance to the paraffin collection which is a major problem in these fields.

The flow line consists of some 3300 ft of 2-in. butyrate pipe, flexible enough to follow the natural contour of the terrain. To make the installation, crewmen placed 20-ft pipe lengths into position along the ground, then joined them quickly and permanently together by means of a solvent cement. The entire 3300 ft were strung and connected in approximately 5 hr.

Before final hookup to well and battery, the completed pipe line was tested under pressure. In normal operation a reciprocating pump forces oil from the well through the line under a pressure of not more than 30 psi. In the test, the pipe checked satisfactorily under 107 lb pressure—a considerable safety margin.

This tough plastic piping has proved successful in other oil fields for systems conducting sour crude oil and salt water, where its good corrosion resistance gives it long service life. The additional advantage that its smooth inner walls resist wax accumulation, and thus help prevent head loss, is expected to prove of special value in this new Canadian installation.

A saving can be obtained by using plastic pipe, when it is suited for the job. This is primarily a matter of pressures, temperatures and sunlight. ★ ★

*Tenite butyrate manufactured by Tennessee Eastman Company.

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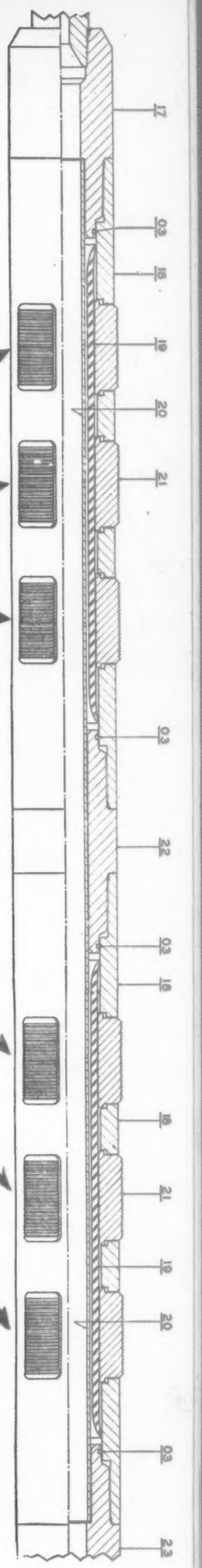

The Eighteen slips of the Wilson Hydraulic Pulling Tool *do not* travel on a tapered cone or mandrel. They are actuated by pump pressure and travel straight out to wall of the casing.

This "no wedging" action is further assurance that this is the "Safest Pulling Tool You Can Run."

Remember . . . with the Wilson Hydraulic Pulling Tool there are no "J" Slots; you do not have to rotate; and it is virtually impossible to stick this tool in the hole because of slip action.

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03 — "O" Ring
18 — Body
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20 — Inner Sleeve
21 — Slips
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A few of the 2600 derricks that dot the surface of Lake Maracaibo, Venezuela.

P 122

Venezuela's Fabulous Lake Maracaibo

This lake field produces nearly 9 per cent of the world's oil supply, has an estimated reserve of 5 billion barrels

LAKE MARACAIBO symbol of oil wealth, has today become one of the most vital strategic areas in the east-west global conflict.

Near the eastern shore of the lake 2600 oil wells—a billion-dollar forest of steel derricks on water—form part of the Bolivar Coastal field, the world's largest single oil-producing area. Along with 3400 wells on shore, this lake field provides nearly 9 per cent of the world's oil supply. Of the world's present crude petroleum production of around 12,000,000 bbl daily, nearly 1,000,000 comes from the Bolivar Coastal field.

Venezuela is the world's number one exporter of oil and the United States is its chief customer. Despite its output of approximately 6,500,000 bbl daily, the United States is not producing enough petroleum to meet its present consumption. Last year the U. S. imported 306,000,000 bbl, of which approximately 70 per cent was Venezuelan oil shipped directly from Venezuelan as well as from refineries at Aruba and Curacao.

During the last war Venezuela boosted its production 75 per cent, from 508,500 bbl per day in 1940 to 885,900 bbl daily in 1945.

Lake Maracaibo, the key area of Venezuelan oil production, is a large body of water in western Venezuela shaped like a pear whose stem is a channel connecting the lake with the Gulf of Venezuela and the Caribbean Sea. It is 115 miles long and 70 miles wide, covering an area of approximately 5000 square miles, about the size of Lake Erie. Nearly 29 per cent of the lake area is under concession to oil companies. The Creole Petroleum Corporation, Standard Oil Company (New Jersey) subsidiary, holds the largest percentage of total lake concessions of almost 1500 square miles. The Mene Grande Oil Company (Gulf subsidiary) owns a series of parcels within a one kilometer strip paralleling the shoreline. The Venezuelan Oil Concessions, Ltd., (Shell subsidiary) has three groups of concessions on the lake and all land concessions covered by the Bolivar Coastal field, which includes the northeastern shore of the lake.

PHOTOS COURTESY HAMILTON WRIGHT

The Bolivar Coastal field was discovered in 1917 when the Venezuelan Oil Concessions, Ltd., brought in a small producing well in the La Rosa field, known as Santa Barbara No. 1. But world attention was not drawn to the area until five years later, when, in 1922 Shell's fourth well, Barroso No. 2, suddenly blew the drilling tools out of the hole and turned into an oil gusher that flowed for nine days at an estimated rate of 100,000 bbl per day. Underground sands automatically plugged the hole at the end of the ninth day.

Drilling operations were undertaken in 1925 in 10 to 15 feet of water without precedent in oil field work as a guide. Wooden piles and timber foundations were used. But the wood, treated or not, hard or soft, failed to withstand the ravages of the teredos, a water-born ter-

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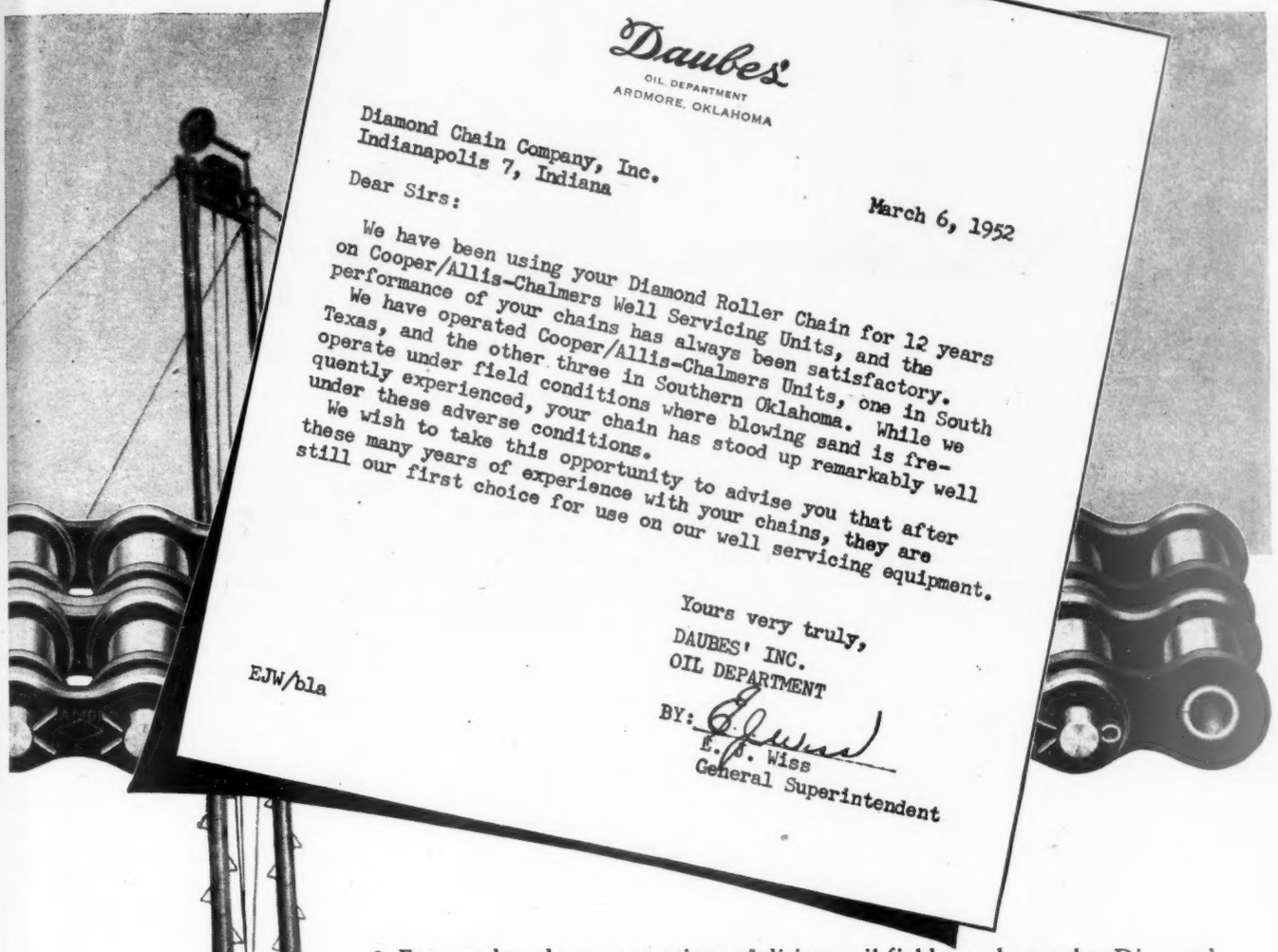

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ARDMORE, OKLAHOMA

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March 6, 1952

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We wish to take this opportunity to advise you that after these many years of experience with your chains, they are still our first choice for use on our well servicing equipment.

Yours very truly,
DAUBES' INC.
OIL DEPARTMENT
BY: E. J. Wiss
General Superintendent

EJW/bla

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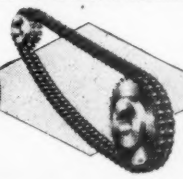
DIAMOND  **ROLLER CHAINS**

One of the Cooper Allis-Chalmers Well Servicing Units equipped with Diamond Roller Chains operated by Daubes', Inc., Ardmore, Okla.

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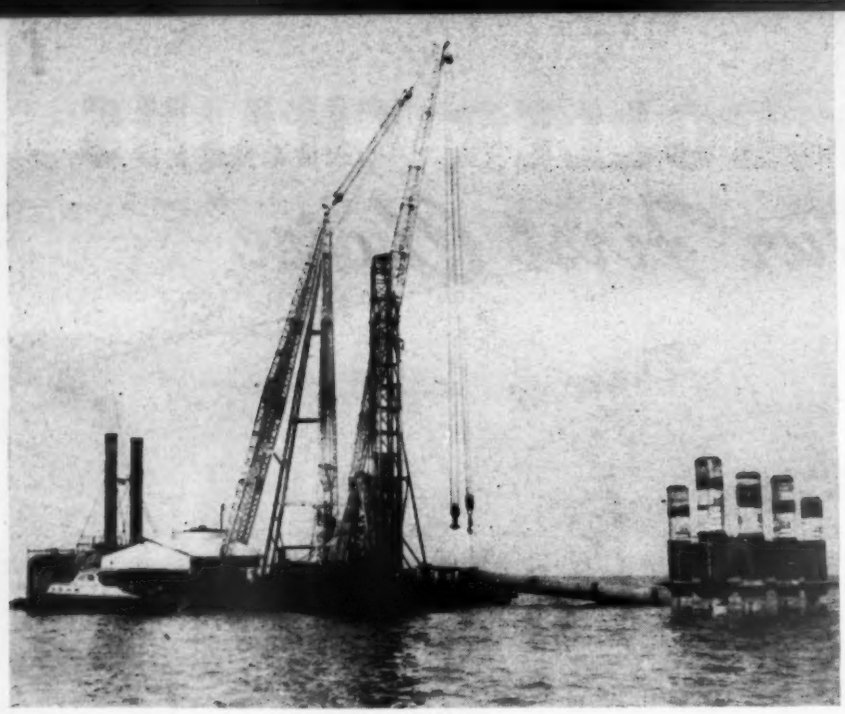
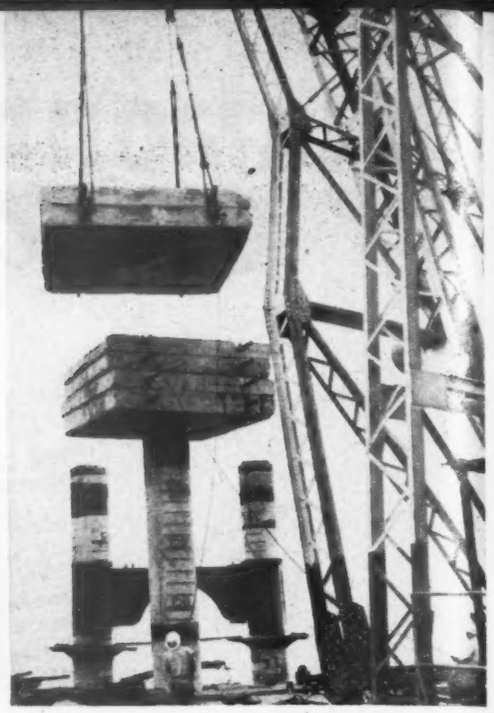


Pile driving barge preparing to sink caisson on which flow station will be built.



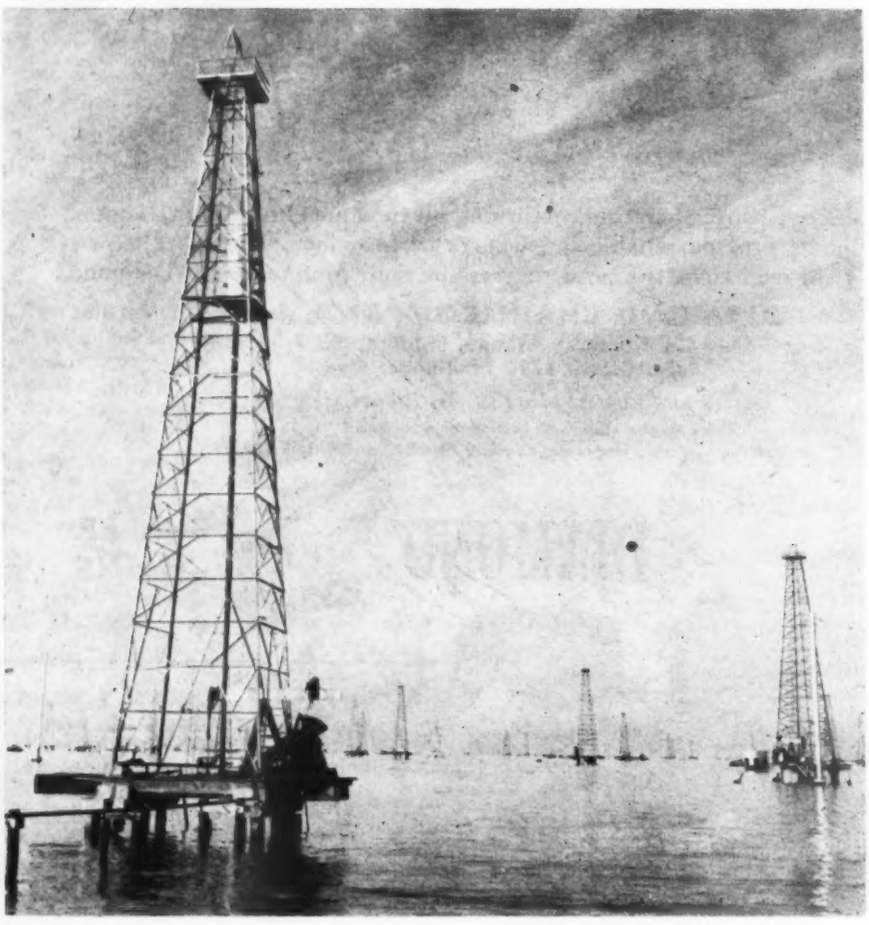
Sinking a 160-ft cement and steel caisson.

mite very active in tropical waters.

In 1927 the Raymond Concrete Pile Company installed the first concrete well foundations using 17 concrete piles and a concrete base and a wood or steel substructure. Auxiliary foundations, being necessary during the drilling of the well, still employed 80 to 100 wooden piles that were removed after drilling was completed.

The wooden pile auxiliary foundations were completely eliminated when land drilling techniques were discarded and accessory equipment was mounted on barges that could be moved from location to location as wells were drilled.

Of the 2600 wells on the lake 59 per cent are flowing, others like one in foreground, are operating on pumps.



Creole developed drilling, repair, and pipe-laying barges. One of the largest, a diesel electric drilling barge known as the "Queen Mary", was later sold to the Arabian-American Oil Company and is at present drilling wells in the Persian Gulf off the coast of Saudi Arabia.

After a long struggle with the problem of finding a satisfactory foundation, the engineers came up with a hollow-pile, or caisson-type concrete foundation that met all the requirements, using steel shells with 5-in. thick walls.

Now, however, use of caissons has been abandoned for economic reasons and this year Creole has begun at La Salina the construction of mammoth concrete piles, 200 ft and more in length, to serve as foundations for well platforms.

When the wells are completed, the oil is produced either by natural flow, mechanical pumping, or artificial lift methods. Fifty-nine per cent of the lake wells are natural flow wells where the natural gas pressure below the ground is sufficient to force the oil (mixed with gas and sometimes with water) to the surface. Thirty-seven per cent are pumped, where natural pressure is incapable of forcing the oil to the surface. Artificial lift methods are employed to make wells produce when the natural reservoir pressures decline to a point where they cannot force the oil to the surface. The injection method, forcing water, gas, or air under pressure into the producing formation to drive oil to the well, is a common practice. Four per cent of the lake wells are on gas lift.

The new wells are drilled according to a basic spacing pattern of a 600-meter grid, which covers the producing area. Wells may be drilled more closely together, but always according to the same pattern, i.e., at 300 or 150 meters. Some change in the basic pattern may take place when off-set wells are drilled for competitive reasons. The basic pattern has been set as a result of engineering studies of the maximum efficient producing rates. * * *

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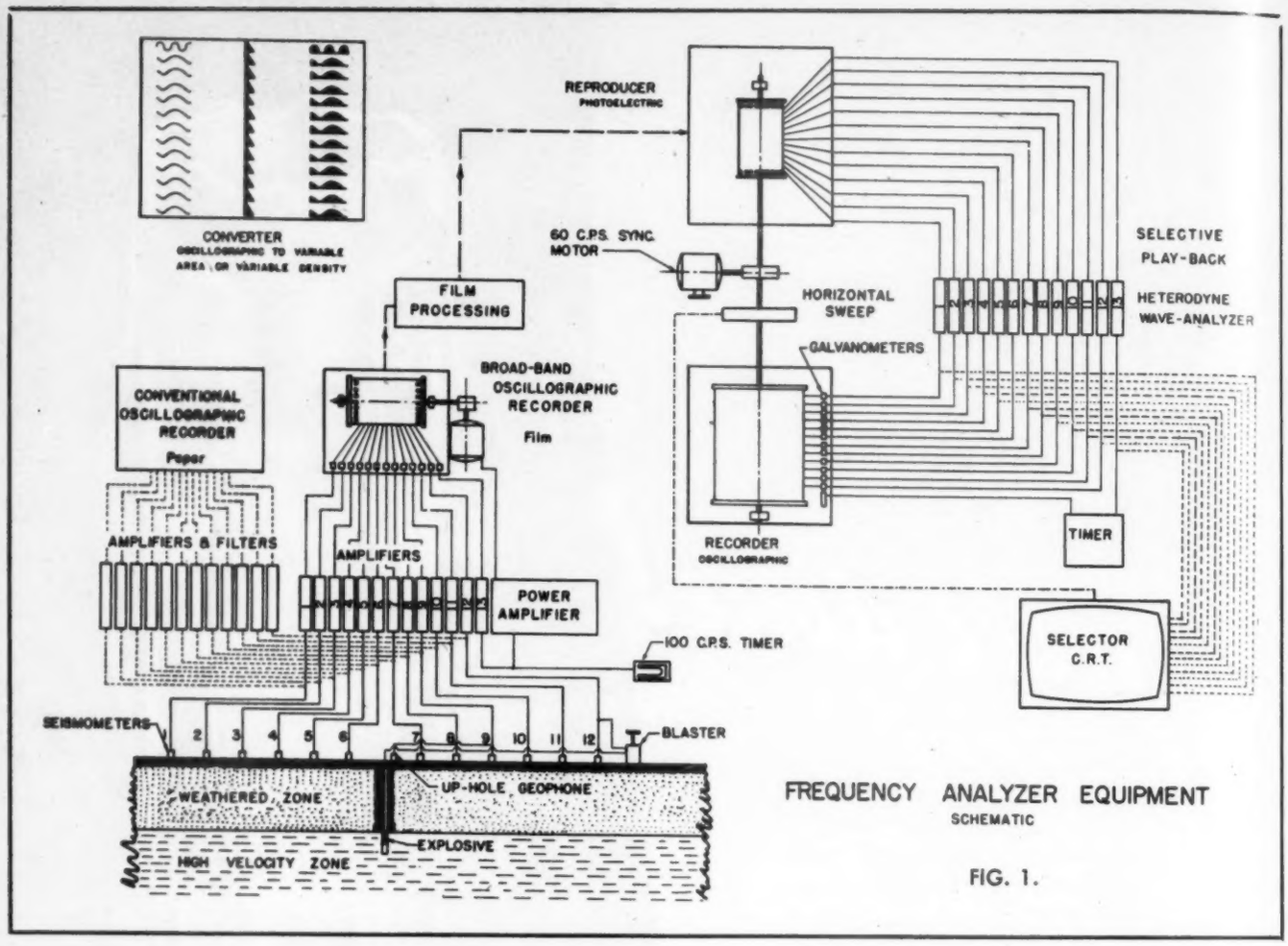

FIG. 1.

Play-Back System Aids Seismic Exploration†

RICHARD SNEDDON*

ONE of the most interesting developments of recent years in the general field of geophysical exploration is the method and instrumentation devised by Dr. J. Jay Jakosky[1] and John J. Jakosky, Jr.,[2] for recording seismic wave energy on a film that can be played back as often as desired; and in which by varying the circuit parameters any especially interesting components may be accentuated and examined *ad infinitum*. This, of course, is most useful in the so-called marginal areas where records of poor quality are generally obtained, and the elimination of major interference frequencies is necessary to effective interpretation.

The idea of recording on a reproducible medium did not originate with these investigators but so far as we know they are the first to come up with the essential equipment modifications, adaptations, additions, and most important of all—a highly satisfactory technique. All this didn't take place overnight. Early efforts employed several types of sound recording and reproducing equipment, mostly of the phonographic type, using wire and tape magnetic recording, and variable area and density photographic film recording.

It was found that almost any of the better known systems for recording and reproducing sonic energy could be used in seismic work. The final choice of an oscillographic trace photographic recorder thus became a matter of evaluating the pertinent factors and deciding on the most effective, convenient and economic combination. For example, while magnetic recording obviated the necessity for processing photographic film, it was objectionable because it required bulky, complex, and costly equipment. Actually, the magnetic recorder and its power mechanism weighed more than the entire seismic unit to which it was attached.

The oscillographic type photographic recorder, on the other hand, added a mere 30 lb to the normal load. Apart, also, from the considerations mentioned, it was noted that the magnetic recording wave gave a signal/noise ratio about 5 decibels higher than the photographic method. This differential, however, was eventually dissipated because the greater noise developed in photographic

†Abstract of a technical paper by J. J. Jakosky and John Jakosky, Jr., entitled "Frequency Analysis of Seismic Waves" to appear in the October, 1952, issue of "Geophysics," of the Society of Exploration Geophysicists.

*Pacific Coast Editor.

[1]President, International Geophysics, Inc., Los Angeles, California.

[2]Chief engineer, International Geophysics, Inc., Los Angeles, California.

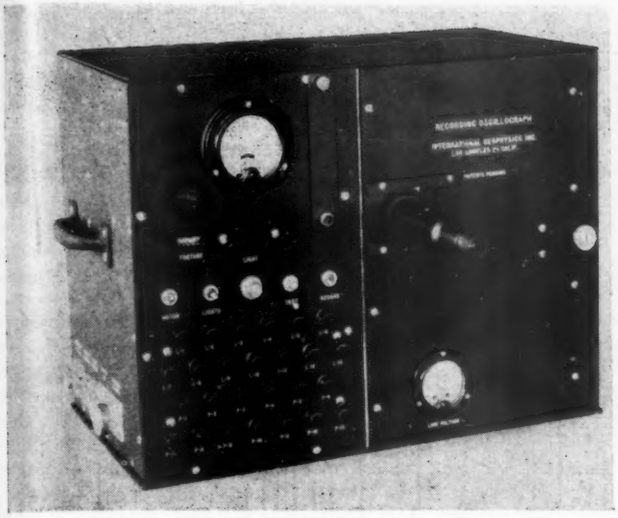

FIG. 2. Broad-band recorder and amplifier unit.

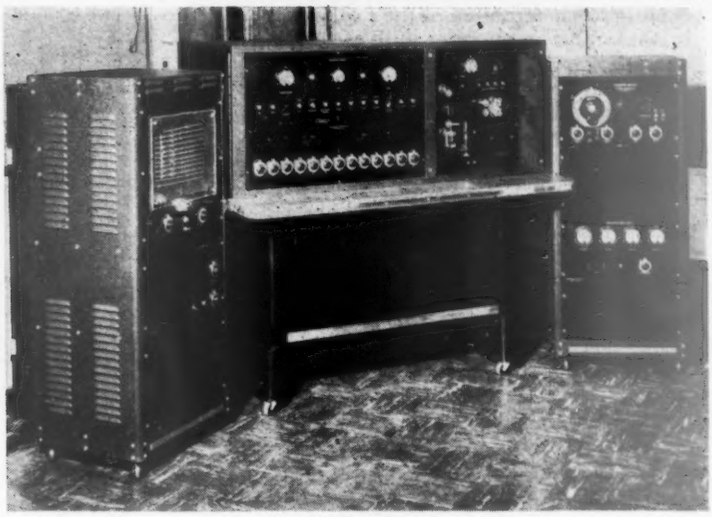

FIG. 3. Wave analyzing equipment.

recording lies well above the seismic frequencies, and with normal filtering of the seismic band, the ratios for the two systems seem to be about even.

The photographic method has the virtue of simplicity, and is desirable for other reasons. Early in the investigation it became evident that direct oscillographic recordings have certain advantages over those of the variable area or variable density type. Geologists and geophysicists are familiar with the interpretation of oscillographic phenomena, and much of the computing as to first arrivals, uphole time, weathering, etc., can be made directly from the oscillographic recording without first playing it back. This greatly expedites both the computations and the ultimate interpretations.

The precision and accuracy of the instruments is highly important. The electronic recording and reproducing equipment must be reliable and enduring. It must function with high fidelity and have stable gain and phase-shift characteristics to permit quantitative measurement. Film travel in the recorder and in the reproducer must be in complete synchronism and must be sufficiently restricted as to flutter and "wow," to maintain an accuracy of $\pm$ one millisecond.

Functionally, the operation is designed to produce a broad-band recording in the field, and then by subsequently playing back this recording, to make as many component separations as circumstances indicate to be desirable. This will largely be determined by the character of the area under investigation, and the ultimate purpose of the survey.

A schematic diagram of the complete dual-recording set-up is shown in Fig. 1. Any desired mixing and filtering may be used in making the conventional paper record, and the paper may be developed after each shot for immediate inspection. At the same time, in parallel with the conventional system is a special oscillograph for recording the reproducible broad-bands. When necessary adjustments have been made, the oscillographic camera operates through a relay that is in turn operated by the motor switch on the paper camera. The seismic energy appears as oscillographic traces on sprocket drive film, the sprocket being driven by a 100 cps synchronous motor, equipped with a power amplifier that is driven by a precision tuning fork. This fork also operates the galvanometer that places the timing wave on Trace 13.

The broad-band recorder and amplifier unit is shown in Fig. 2. The optical and electrical components are in the left section of the cabinet, and the mechanical film transport equipment in the right section. Ordinary 35-mm motion picture film is used for 13 channel recordings and 70-mm film for the 25 channel type.

Specially designed ribbon galvanometers (600 cps), with a power output of less than one milliwatt for the full excursion of the oscillographic trace, are used by the recorder. These galvanometers are driven by tiny, high fidelity, tube amplifiers, comprising largely the gain and control stages, with low and high cutoff to establish the recording limits. Such sharp filtering and mixing (if desired) takes place subsequently when the film is played back through the reproducer. Adjustment of the trace amplitudes is made through the use of a magnifying telescope, and the footage of film exposed is recorded by an automatic measuring device.

Completed film recordings are developed in the usual manner, in the computing office (not in the field). This takes almost 45 min, after which the roll is cut into sections, each covering the broad-band section from an individual shot. The sections are then spliced into loops for observation in the reproducer. In the play-back, the film loop cycles continuously through the reproducer, and is so placed in the device that each trace intercepts a separate portion of illumination directed from an exciter lamp to a photocell.

The excursions of the oscillographic trace as it moves past the scanning slot, combined with a light wedge that varies the intensity of the illumination as the position of the trace alters, cause corresponding variations in the output of the photocell actuated by that trace. The photocell output is then amplified and passed through the desired electrical circuitry.

As the investigators are primarily interested in selecting certain frequency components of seismic waves, they pass the amplified output from each trace through a specially designed heterodyne-type wave-analyser, and separate electrically by filtering that damps out everything but the frequency component of immediate interest. The filtering may be of any desired band width and either cut-off edge of the filter may be placed at any position on the frequency spectrum. A multi-stage, cascade LC band-pass filter system, with 40 db/octave slopes on both the high and low frequency sides, is used.

Changes in the filtering or other electrical parameters influence the character and line-up of reflections at any desired investigation depth but such effects may be observed visually on a 16-in. cathode ray selector tube. Having determined the requisite condition, a regular paper record is made for computing and interpretation. Using the 100 cps timing wave, recorded on film in the field, when the original broad-band record was made, timing lines are placed on the new record by means of a glow-tube timer.

The wave analyzing equipment is illustrated in Fig. 3. This, of course, remains at the central computing office and consists of mixing, filtering, and expanding circuits. The center cabinet holds the main control panel, and is comprised of separate gain controls for setting the level of each channel, and the mixing and control circuits. At the right is the film transport mechanism. The cabinet at the left contains the cathode ray tube and electronic timer. The right cabinet houses the heterodyne wave-analyzer, a compressing and an expanding unit for accentuating certain components, and the electronic power supply.

The seismic impulse in normal geophysical prospecting results from the detonation of a carefully engineered

explosion. The duration of the explosion is measurable in micro or milli-seconds, depending on the character and quantity of explosive, shot-hole environment, and loading conditions. It is well accepted that the initial wave front is very steep but is quickly and considerably modified by environmental conditions in the immediate neighborhood of the shot-point, and thereafter is rapidly and progressively reduced in steepness even within a few tens of feet. The rate of change is determined by its own geometrical expansion and by the transmission and reflection characteristics of the media through which it passes.

Generally, the initial energy consists of a relatively wide band of frequencies —from a few cycles to many thousands of cycles per second. It has been shown by previous investigators that in its passage through the earth, this broad-band impulse loses higher frequencies much more rapidly than lower ones, due mostly to absorption and scattering. As for the lower frequencies, there has been recognized a frequency discrimination for reflected waves that is believed attributable to interaction between reflections from top and bottom interfaces of a given reflecting bed. It appears that when the bed is an odd number of quarter wavelengths thick, the energy from the lower interface will be of opposite phase and hence will to some extent neutralize the energy from the upper interface. When the bed thickness is an even number of quarter wavelengths, the reflections from the two interfaces are of the same phase, are consequently additive, and a corresponding increase in wave motion takes place.

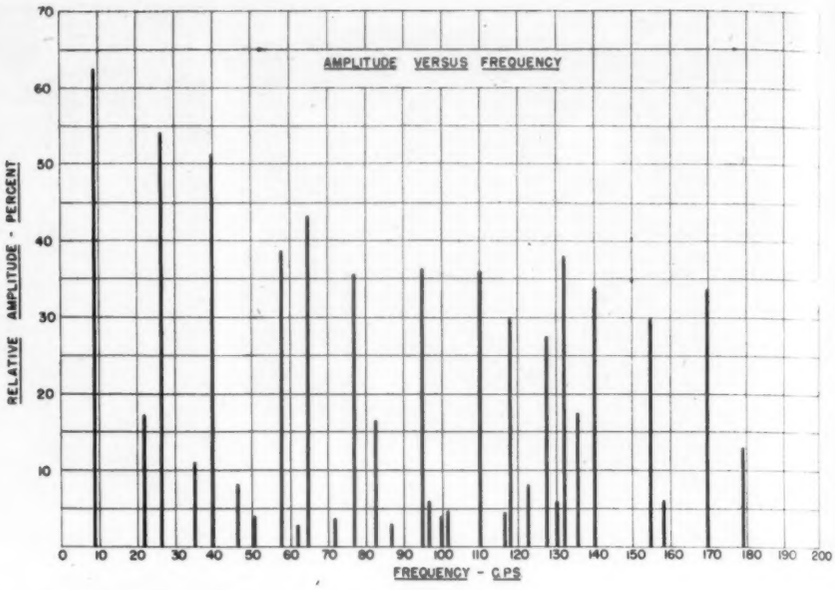

FIG. 4. Frequency spectrum from Louisiana area.

At the longer wave lengths, where thickness of the beds is much less than one quarter wavelength, it is believed the reflection co-efficient drops somewhat directly with frequency, and a stratification of relatively thin beds tends to be homogeneous to the longer wave lengths. Low frequency energy is not reflected appreciably and comes back to the surface only by refraction. In general, it may be considered that the earth acts much like a wide pass filter. In each area some of the reflected frequencies will be amplified while others are reduced. Reflected bands of signal energy will be superimposed on interfering energy components which come back to the surface by refraction, air waves, and surface waves—all of which are received by the seismometer and duly recorded.

Actually, the total energy received by the seismometer is a very complex vibration with mostly random relationships in amplitude, phase and duration of its components. A frequency spectrum of the reflections from an area in Louisiana is shown in Fig. 4. This is more or less typical, illustrating the relatively greater amplitudes at the lower frequencies, and the loss of energy at the higher frequencies. The energy distribution is also affected by the peculiarities of the seismometer itself and the manner and place of its contact with the ground. In the test illustrated in Fig. 4, a 0.7 damped, flat response seismometer with a natural period of 6.5 cycles was used. With a conventional higher frequency peak instrument, an accentuation at medium frequencies is to be expected, the degree depending on the extent of damping.

A poor shooting area, contrary to the common belief, is one that has too many reflection bands, and from which there is too much reflected, refracted, and random energy with numerous interfering bands at about the same energy level. On the other hand, good results may be expected where the reflected bands are well separated in their time of arrival and have an energy level above the background noise of other interference. When such conditions prevail, little treatment of any sort is required to obtain records with the requisite visual clarity to yield reliable information. If the higher energy components are not in themselves of prime interest, however, it is to be remembered

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that they may mask lower energy components that are.

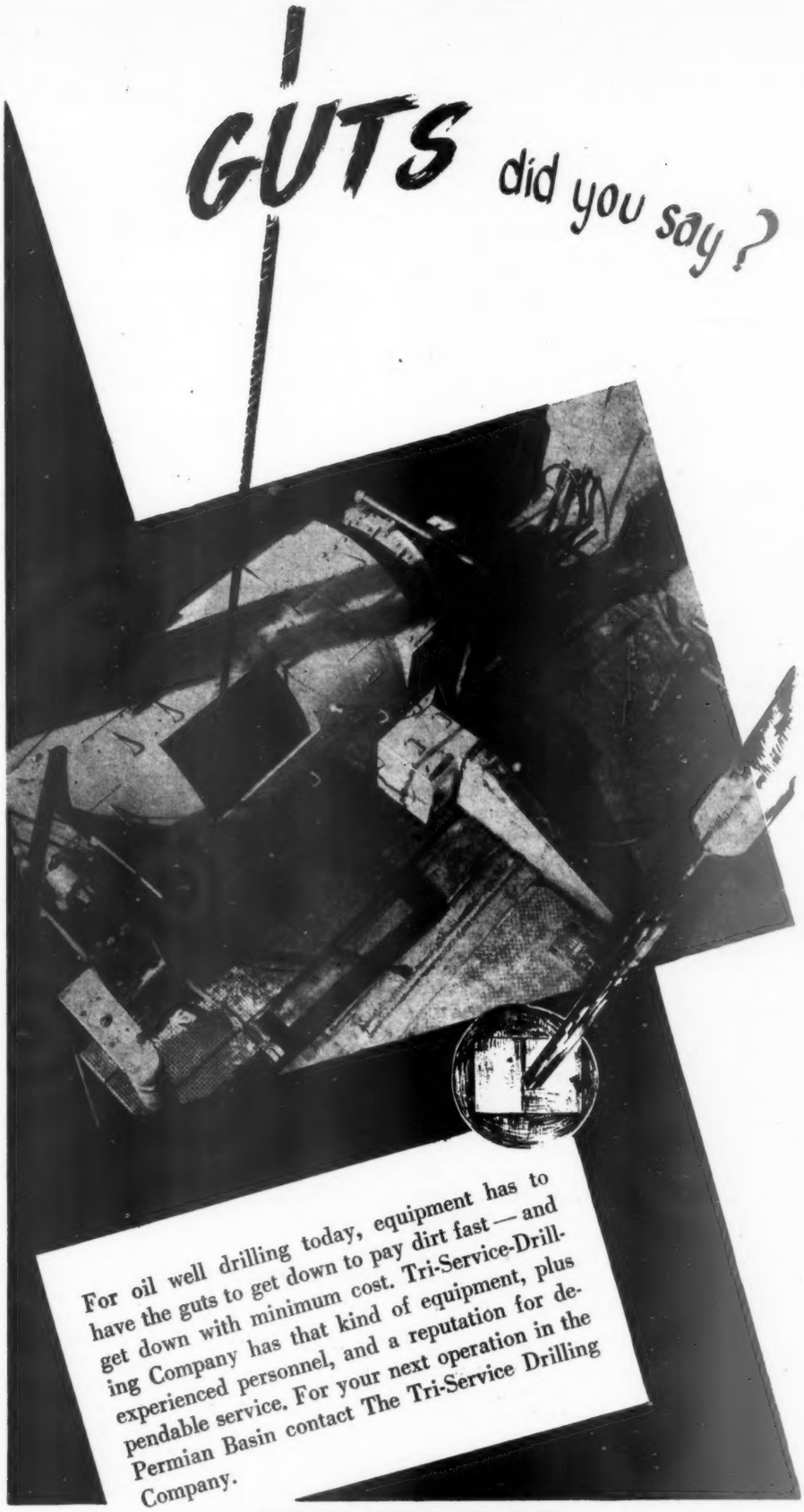
There are two well recognized types of interfering energy. The first is represented by seismic energy that occupies a place in the frequency spectrum outside of the reflecting bands being considered. The second type may be between two or more reflections, or between a reflection and some affecting influence within the pertinent reflecting bands. The first type can be handled very well by employing a high pass filter, so positioned in the frequency spectrum that its lower cut-off will reject the low frequency interference. By the same token, interference in the high frequency section of the energy spectrum, such as wind, shot noise, and high frequency surface beds, can be eliminated by employing a filter with appropriate high frequency cut-off.

The second class of interference cannot be disposed of quite so easily. The components in this case offer a much more critical filtering problem, particularly in those areas where the geologic column has bedded strata, the thicknesses and reflection co-efficients of which are similar. These produce reflected energy components of about the same amplitude, lying within a narrow range of the frequency spectrum. Sharp filtering is necessary to separate the interfering frequencies and obtain a usable signal/interference ratio.

Narrow filtering implies the use of a peaked or resonant type filter passing a narrow band width at the center or peak frequency of its amplitude-frequency curve. Such a filter is usually low damping and has a considerable "ring" that tends to destroy the character of the reflected energy. This type of filter is of no value where the reflections follow each other at time intervals that are less than the duration of the ring. Under these conditions, the separate reflections blend into a continuous ring, or train of waves, which lack the differential characteristics that would permit either correlation or identification of the individual reflections.

Sharp filtering is accomplished by using a multi-section, non-resonant type filter whose frequency-amplitude curve has steep sides and a fairly flat-top portion of relatively wide band width. This type of filter is effective in discriminating between two components of different frequencies, by so adjusting that the desired component falls within the band width of the filter, while the undesired component falls outside. When this takes place, the rejection is brought about by the steep side of the filter curve and not because of a peak or resonant condition. Also, by using a sufficiently wide band, the character of the desired reflection is preserved and effective identification and correlation are obtained.

Reflection quality is gaged by line-up, repetitive pattern, amplitude, envelope, and alignment curvature. The accuracy of dip computation depends on alignment and the outer traces of the record are of paramount importance. According to the investigators, minor deviations from the alignment curvature may at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times be overlooked, but serious interruptions in slope must be taken seriously. Structural discontinuities may cause apparent mis-alignment. So also may topography and weathering, and phase shift and modulation. Phase shift and modulation, resulting from interference between the desired reflection and the undesirable energy, has an effect that cannot be computed and can be minimized to about the same extent as the interference itself is minimized.

Low frequency interference is usually caused by direct or surface waves, shallow refracted waves, and other more or less random energy, including air waves. These interferences are picked up by the seismometers and are often responsible for amplitude on the record, larger than the desired reflected waves. When such waves overload the seismometers and/or amplifiers at the instant the desired reflections arrive, they impair the quality of the record. Even when the random amplitudes are below the overload point, they still confuse the issue and make it difficult to segregate the wanted reflections. Because of the high energy of direct waves in the immediate neighborhood of the shot point, it is normally hard to pick a reflected wave in the initial part of the recording period. Any energy having a level above the desired reflections will operate the AVC system of the amplifiers and correspondingly modulate the amplification of the reflections. This frequency occurs when high amplitude surface waves actuate the AVC, pinch down normal amplitude of the reflections, and thus impair the line-up across the record.

Fig. 5 is a recording from the vicinity of Stillwater, Oklahoma, and illustrates interference from both high and low ends of the spectrum. Record 1 is the original broad-band recording. Examination will show the first arrivals at A traveling at a velocity of 7200 ft per second; and two low frequency disturbances at B and C. Super-imposed on the traces are some higher frequency energy of about the order of 100 cps, and at D and E a line up of reflected energy is indicated.

The low frequency components are shown in Record 2. They are the 21 cps surface longitudinal waves, B, traveling at a velocity of about 1090 ft per second. Record 3 shows the high frequency components. They are reflections at the desired depth range coming in at a frequency of 68 cps.

It will be noted that the first arrivals are not evident on Record 2, the low frequency record, although they are easily seen on the original broad-band record. These first arrivals are the direct and shallow refracted waves which because of the short distance of travel in this instance, include a fair percentage of high frequency components. Record 1 also offers proof of the well accepted fact that to obtain sharp first arrivals, the high frequency components should be passed by the filtering system during the initial part of the recording.

Fig. 6 is a record taken in the Haskell Reef area of Texas, where conventional procedures yield poor records. It illustrates interference between reflections. Note reflected energy cutting across the record at K, J, I, B, A, and D; and the low frequency surface wave (17 cps) cutting across Record 2. In Record 3, 47 cycle reflections are shown at J, I, B, F, and D, and a 62 cycle reflection may be seen at K in Record 4. The travel time relationship would indicate that this latter reflection at K is in reef material of Middle Pennsylvanian age. The reflection at T is near the bottom of the Pennsylvanian and the one at B is probably from the Ellenberger. Attention is drawn to the reversal in apparent ΔT between the shallow reef reflection at K (+9 milliseconds), and the deeper reflections from below the base of the reef (–6 at B and –7 at D).

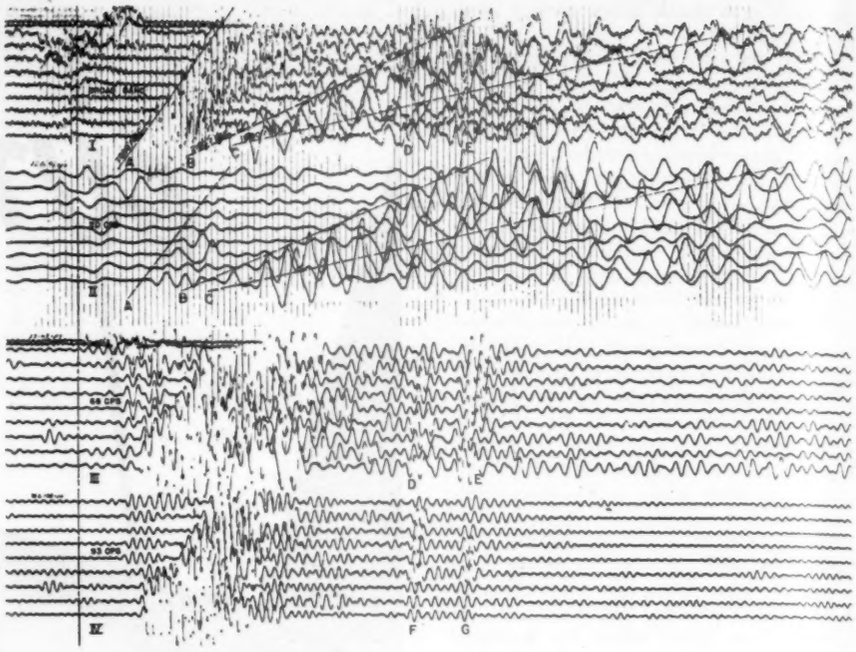

FIG. 5. Interference from high and low ends of spectrum.

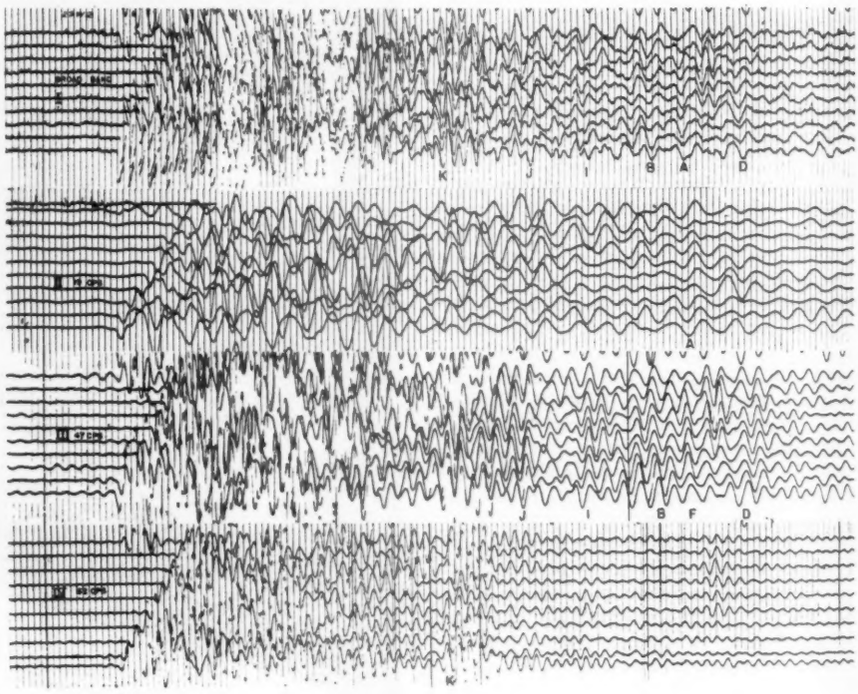

FIG. 6. Shows interference between reflections.

When interference occurs between reflections of the same amplitude, errors may be introduced in the observed values at ΔT, as illustrated in Fig. 7. A shot point is indicated at SP with the near seismometer designated S, and the far one, S_{10}. If then two reflections of about equal magnitude, say 30 and 40 cps, from the same reflecting horizon, arrive simultaneously at S_1, the relationship will be as illustrated. Assuming that A represents the first trough for the higher frequency wave, and B represents the first trough for the lower frequency wave, and since the two troughs have

the same relative phase angle, their effects will be additive and will result in a trough at T. By the same process of reasoning, the peaks may be located at C and D, with the resultant peak at T_2.

The relationship at the far seismometer is indicated in Diagram 3. The wave, traveling a greater distance, produces the relative phase displacements as illustrated, making a greater shift in the resultant trough, T_3, and the resultant Peak, T_4. This means that the value of ΔT will be more than its true value when the waves exhibit phase relations as shown, and will be of lower value for reversed conditions. If the pulses overlap sufficiently long, the ΔT values will be greater for the second series of troughs and peaks, a circumstance that frequently furnishes a check on the presence of interfering reflections which are additive and slightly out of phase. This condition causes the ΔT values across the record to vary progressively between the first set of troughs and the first set of peaks, the second set of troughs and the second set of peaks, and so on.

This type of reflection has character across the record and when interfering components differ sufficiently in phase, will break into two separate legs. The required phase difference between the two reflections depends on frequency differences and filter characteristics. The more ring in the filter, the greater must be the frequency difference. If the separation is satisfactory the distinctive components will have substantially the same ΔT value. Usually, either of the component reflections may be recorded by sharp filtering if their frequencies are sufficiently different to allow the cut-off edge of the filter to be positioned between the two.

Fig. 8 is part of a record taken in Louisiana and shows interference between waves of about the same amplitude. Wave motion at periods A and B for a 36 cps wave, meeting interference from a 25 cps wave, is shown in the top record. The step-out time between the two outside traces is –3 milliseconds at Point A, and –9 milliseconds at point B. The 36 cycle component with nearly all of the interference removed is shown in the lower record. The step-out time is about –6 milliseconds on each reflection, which is in agreement with tie-in times to the adjacent profiles of the traverse, and probably represents normal values.

The purpose of Fig. 9 is to illustrate the effect of filter width on record character. On top is an original broad-band recording from Outlook, Canada. The second record was obtained through a 12 cps wide filter; the third through a 30 cps filter, and the fourth through a 40 cps filter, all being centered at 45 cps. As the filter width is extended, more interfering energy is admitted, and changes take place in the character of the record, the major interference in this instance being caused by a 54 cps component on the high side of the reflections centered at 47 cps.

As the band width is extended, it is interesting to note the increasing sharpness of the first arrivals, the increased

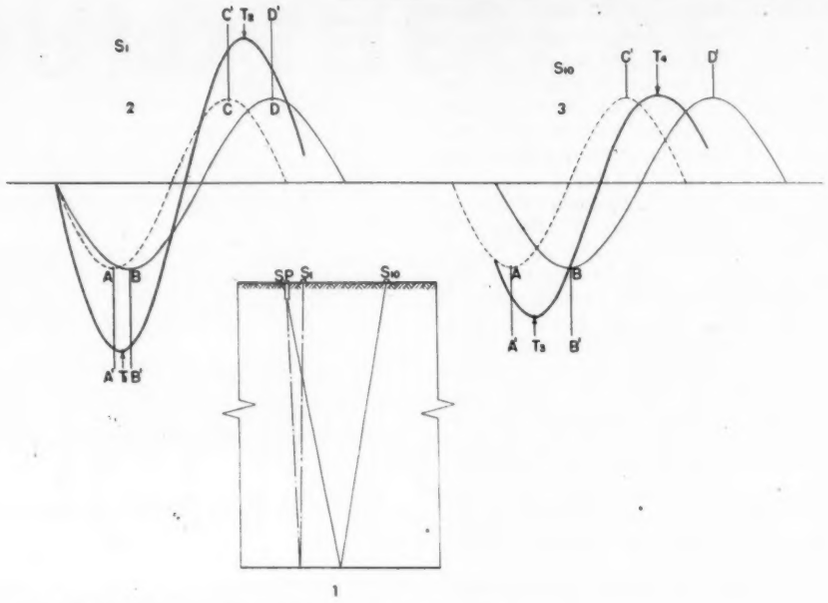

FIG. 7. Interference introduces errors in values.

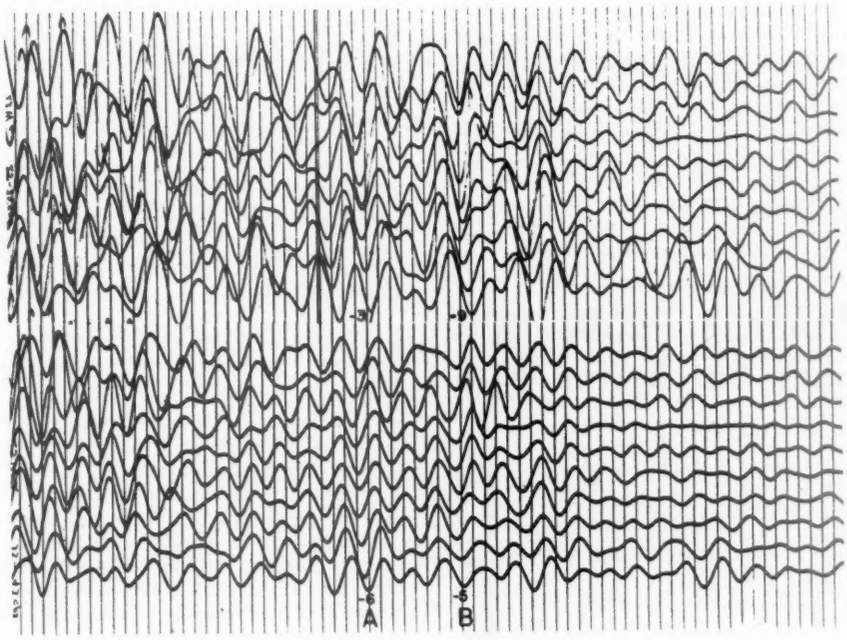

FIG. 8. Shows interference between waves of same amplitude.

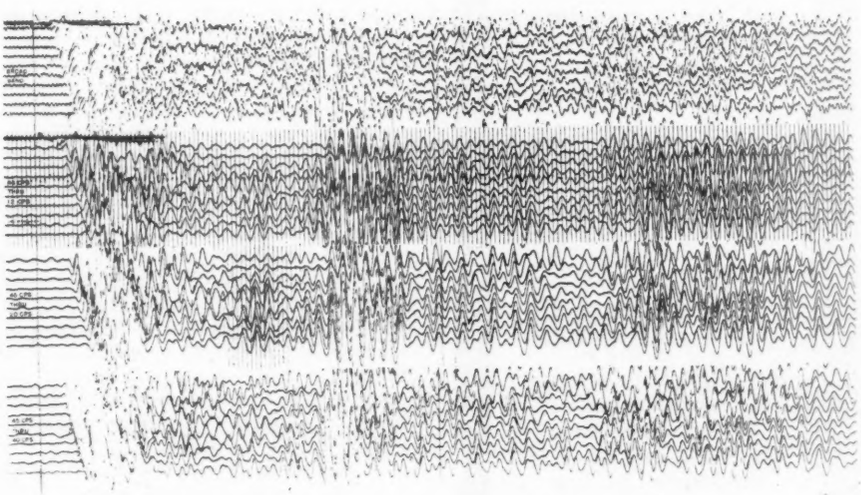

FIG. 9. Shows effect of filter width on record character.

record character, and the better separation. The character of the reflections is destroyed by the ring of the 12-cycle filter, which also masks the reflections that follow the big reflection. Discrimination is best accomplished here by using the edges of a broad-band filter rather than the peak of a narrow filter.

A record from the Shaunavon area in Canada is shown in Fig. 10. Here a 20 cps filter, centered at 35, 54, and 74 cps, was used, and it is to be observed that 35 cps reflections were received from a greater depth after the big reflection. The 54 cps reflections improve the detail in the middle of the record but are missing after the big reflection. The 74 cps reflections improve the detail on the shallow part of the record. These filtering tests, made at the same amplifier gain, were effective in producing a fairly good comparison of the relative amplitudes of the different frequency reflections in the test area.

Fig. 10 also brings out one advantage of the broad-band recording technique in this area. The three lower records have filtering frequencies so different that, because of the narrow filtering required, two or three shots would have been necessary to bring in the reflections. Broadening the filtering to cover two or three reflection frequencies was ineffective. The desirable procedure here was to use a single shot with broad-band recording, playing the record back subsequently through the desired narrow filtering. This yields results equivalent to what might be obtained from two or three shots. The saving in explosives cost and crew time is obvious.

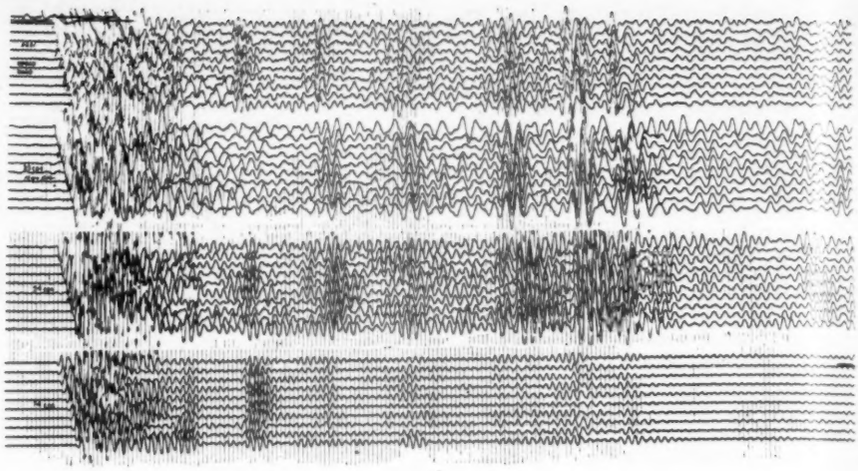

FIG. 10. Single shot with broad-band recording.

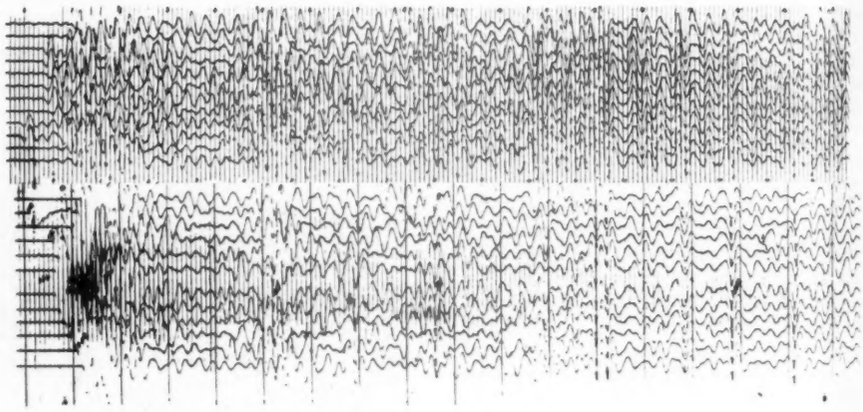

FIG. 11. Top record is play-back used for computing.

There seems to be little doubt, indeed, that the play-back technique has an important place in geophysical prospecting. As already intimated, its main application is in the marginal areas where records of poor quality are usually obtained. The adoption of the right type of filtering is apparently rather simple to determine when playing back the film. For the marginal areas referred to, it was found necessary in most instances to use only enough filtering to remove the major interference frequencies lying above or below the band-width selected. This is usually about 40 cycles wide and so positioned in the spectrum as to include both high and low frequencies.

The play-back, as might be expected, is made in the laboratory and not in the field. This is a process that gives the reproducer operator a chance to do some independent research. He can experiment with any combination of filtering, mixing, amplitude, and modification, he cares to try, all in very quick time. When his observations on the oscilloscope tube indicate that the optimum results have been secured, he can then make the paper record for computing.

This general result is illustrated in Fig. 11, in which the top record is the play-back used for computing, while the lower one is the original conventional recording obtained in the field. Both records contain all the essential elements, but the clean-up speeds interpretation by emphasizing pertinent characteristics; facilitating correlation of the computed results; and requiring the minimum of adjusting in the final interpretation. Enough time is saved in computing and interpreting by the play-back technique, to more than offset the play-back time itself and it is the experience of the investigators that the quality of the records can be raised one or two grades by this procedure.

It is quite obvious that this entire development is of real consequence to the oil finding scientists. We have long contended that one of the greatest influences in our continued technological advance is an increasing capacity to measure smaller and smaller increments of everything. The effectual definition and design of the play-back technique by the Jakoskys is a refinement of method that should be classed in this same category. It certainly opens the way to a more intimate study of seismic exploration in all its aspects, and while it has already proved its value under specific but commonly encountered conditions, there is no doubt whatever that its use, both as a research tool and as an exploratory instrument, is likely to be quickly and largely expanded. * * *

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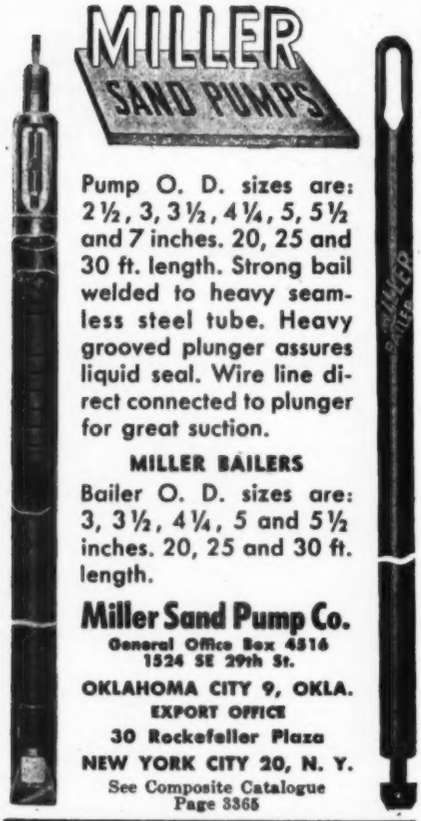

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Side Door Choke and Chemical Injector Improve Production

A NEW or improved drilling, completion, or production method developed within the industry from time to time often sets up a chain reaction all along the line. One good turn calls for another, as it were.

Otis Pressure Control was going along very well with its side-door choke, a sub-surface production tool it has marketed for several years and which worked very nicely in both singly and dually-completed wells.

About two years ago a new completion process—formation-fracturing—began to have an influence on the side-door choke. In September a new "Type A" side-door choke assembly was announced. It has an extra-large by-pass area—especially for formation-fracturing and other operations requiring a large conduit through the assembly. The flow passage of conventional side-door assemblies is through the bore of the choke, which for ordinary wells is an adequate conduit, but which retards injections of gels and other media under extremely high pressure and in large volume.

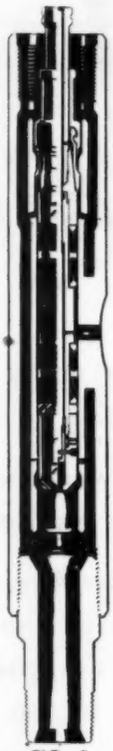

FIG. 1

FIG. 2

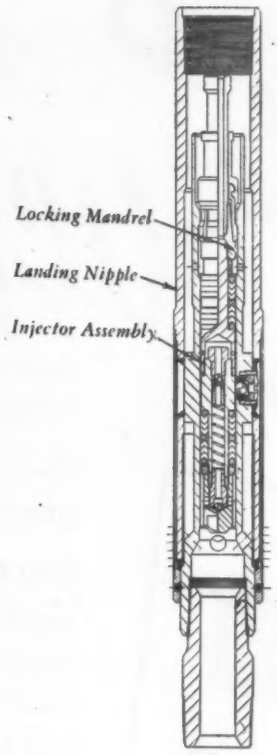

FIG. 4

FIG. 3

FIG. 1. New Type A Otis side-door choke assembly with choke in landing nipple to pack off above and below side-door port to annulus. Flow up or down through tubing by-passes choke. Small valve assembly in lower portion of choke is for equalizing unbalanced pressures to facilitate pulling choke by wire line operations.

FIG. 2. Top view of side-door nipple assembly with choke in place shows large flow area (shaded) of more than 2 sq in.—highly desirable for large-volume fluids under high pressure.

FIG. 3. Top view of conventional side-door assembly; flow conduit is through bore of choke (shaded) which is adequate for average high-pressure wells but which restricts injection of gels, etc., pumped in large quantities, as in formation-fracturing operations. New Type A assembly is not recommended for wells that do not require formation treating.

FIG. 4. Downhole chemical injector developed and now being field tested by Otis Pressure Control. The assembly allows corrosion inhibiting liquid chemicals to be pumped down the casing and into the tubing at a point deep in the production string.

The new Type A assembly consists of a landing nipple mounted concentrically within an outer flow sleeve. A large by-pass area around the seating nipple provides a flow course of more than 2 sq in. for high pressure and large volume flow through the tubing. The new choke also has a built-in equalizing device to facilitate pulling the tool in the event unbalanced or packed-off pressures prohibit full equalization across the choke. Inasmuch as the seating nipple is made up within the flow sleeve, the same size choke can be run in either a 2-in. or 2½-in. string.

Downhole Chemical Injector

Better methods of using improved inhibitors for corrosion control have been continuously made available to operators in fields with highly corrosive oil and gas production. The introduction of liquid inhibitors three or four years ago was a significant advancement, some operators' engineers say; they claim the chemicals in liquid form have certain advantages over stick inhibitors. Too, it's better if either inhibitor is injected so that it will go into solution and coat the tubing wall from the bottom up. To accomplish this bottom-hole injection one or two of the majors in East Texas first experimented with various adaptations of gas-lift valves, etc., but they weren't too successful. Then a year ago a removable tool assembly was devised that would allow liquid chemicals to be injected into a well as needed. Designed by Otis engineers the tool is reasonably successful and is being used by several operators at present, but it will be some time before the field tests meet with Otis' satisfaction and the new assembly is placed on the market for the industry.

The chemical injection device is similar in design to the Otis Type A side-door assembly in that it consists of a landing nipple made up within an outer flow sleeve, and an injector valve device made up on a removable pack-off tool. This latter assembly is to open and close communication between the casing and tubing for the admission of the liquid as it is pumped down the casing and into the tubing. The assembly can be run in and removed on a wire line under pressure as desired.

Thus the apparent solution of the mechanical means of injecting inhibitors may be as significant as the laboratory development of the anti-corrosion chemicals themselves. ★ ★ ★

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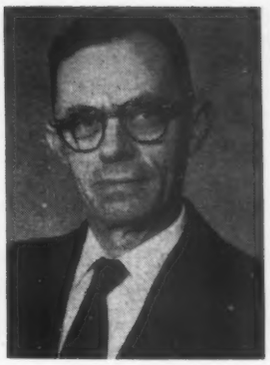

F. G. Boucher

John Eckel

C. B. Scott

Carter Reorganizes Tulsa Research Laboratories

A department to deal principally with development of new methods to improve oil recovery has been organized at the research laboratory of The Carter Oil Company, Tulsa, Oklahoma, Dr. P. S. Williams, chief of research, announced.

The new recovery methods section is headed by Dr. Charles D. Russell. He obtained his doctor's degree in chemistry in 1941 from Duke University and has been engaged in exploitation research since joining Carter in 1946.

"Increased interest in various phases of research associated with the production of oil has made it necessary to expand this work," Dr. Williams stated.

Dr. Eugene M. McNatt, an assistant chief of research at the Carter laboratory was named assistant to the chief geophysicist of Carter. Dr. McNatt joined Carter in 1939 after completing work at Washington University, St. Louis, and the University of Colorado at Boulder. He will be assistant to H. W. Brown, Carter chief geophysicist.

Announcement was also made of the appointment of Sam R. Marsh, Denver, as geophysical supervisor of the newly formed Northern division for Carter. Marsh is a graduate of the University of Oklahoma and Baylor University.

F. G. (Geoff) Boucher was named an assistant chief of research at the laboratory. A veteran of 23 years with Carter and Jersey Standard affiliates, Boucher has been head of the development engineering section. He began work for Humble Oil and Refining Company, Houston, in 1929 as a research geophysicist immediately after graduation from the New Mexico School of Mines and came to Carter in 1940 as a senior geophysicist.

Work of the development engineering section will be divided, with John Eckel heading the new drilling methods section and C. B. Scott taking charge of the new geophysical engineering section. Eckel is a graduate of the University of Oklahoma. Scott, an Oklahoma A. and M. graduate, has 16 years service since joining Carter in 1935.

Geolog Offices Moved

Geolog, Inc., has announced a change in address of its offices. New headquarters are at 1516 Gulf States Building, Dallas, Texas. They were formerly at 501 Continental Building, Dallas.

Football in 1952 was the main topic of discussion by the Houston, Texas, Nomads at their regular September meeting. Attending the meeting were Clyde Lee, coach at the University of Texas and Jess Neely, coach, Rice Institute. Several foreign guests attending the meeting had never seen a football game, but were given an idea of how it is played by a short movie of the highlights of the 1951 Southwestern Conference, produced by Humble Oil and Refining Company. Above are foreign visitors in attendance: Curt Summers, C. M. Summers, Caracas, Venezuela; J. J. J. Van Wiechen, B.P.M., The Hague, Netherlands; W. G. Berry, A. Z. Export SA, Caracas, Venezuela; J. J. Progress, Modern Engineering Company, Houston; H. R. Powell, Shell Caribbean Petroleum, Maracaibo, Venezuela; Clyde Lee; A. R. Gouteyron, Shell Venezuelan Oil Concessions, Maracaibo; and Cecil Griggs, assistant football coach, Rice Institute.

AAODC Holds 12th Meet

The American Association of Oilwell Drilling Contractors held its 12th annual convention in Oklahoma City, Oklahoma, recently. Subjects discussed varied from company-contractor relations to the more technical aspects of drilling operations. Principal speech at the banquet held the second evening of the meeting was made by W. C. Whaley, president of Sunray Oil Corporation. His subject was "The Contractor and the Oil Company."

The significance of geology to the drilling phase of the industry was discussed by Frank Morgan, vice president, Richfield Oil Corporation, Los Angeles, California, A. W. Thompson, president of the Association addressed the meeting in the form of a report on the drilling industry generally.

Gas-Injection Method For Oil Recovery Studied

Greatly increased oil recovery and a longer productive life were gained partly as a result of using gas-injection to stimulate output in one area of the Cabin Creek field in Kanawha and Boone counties, West Virginia, the U. S. Bureau of Mines reported in issuing a descriptive report on the operation. The report gives results of a study made by Bureau engineers in cooperation with Pure Oil Company's Eastern producing division.

Gas-injection, which began in 1935, was successful, and if it had been continued it is estimated that it could have increased ultimate oil recovery in the area studied by an estimated 1,660,000 bbl and extended the productive life of the project to 1970, according to the Federal report. Without gas-injection, water-flooding, or some other secondary-recovery method, however, the area would have reached an economic limit by 1950 with a cumulative output of only 3,990,000 bbl, as compared with 5,650,000 bbl which Bureau engineers estimate would have been produced by 1970 using the gas-injection method.

The report was written by Joe N. Magee and Sam S. Taylor, petroleum engineers at the Bureau's Franklin, Pennsylvania, office. A free copy of "Report of Investigations 4899" can be obtained by writing the Publications-Distribution Section, Bureau of Mines, 4800 Forbes Street, Pittsburgh 13, Penna.

Texas Oil Output in 1952 May Top Peak Year, 1951

Texas crude oil production in 1952 may equal or surpass the mark set in the peak year 1951 when the state produced 1,010,000,000 bbl, the Texas Mid-Continent Oil and Gas Association has estimated.

Using September allowables in calculating production throughout the fourth quarter of this year, the Texas Mid-Continent estimated 1952 crude production in Texas as reaching 1,037,000,000 bbl.

Production for the first nine months of 1952 was 755,000,000 bbl, compared with 747,000,000 bbl for the same period in 1951. A strike-induced production cut in May dropped daily average production to 2,163,000 bbl, as against the previous month average of 2,920,000 bbl. For September of this year the daily average ran over 3,000,000 bbl, or 7 per cent above September 1951. With demand at high levels, the state's petroleum industry could pass the 1951 mark. It is also estimated state refineries processed 63 per cent of Texas' crude output.

Mississippi Offshore Test Abandoned as Dry Hole

Gulf Refining Company and Melben Oil Company have abandoned the first offshore test made in Mississippi as a dry hole. Situated in the Mississippi Sound, the No. 1 State Mississippi was taken to a total depth of 10,751 ft. Test was off Hancock County.

Melvin C. Kruse, driller for Loffland Brothers, is shown at the brake in Shell Oil Company's Jumping Pound Unit No. 8. The well is to be drilled to about 10,000 ft.

Atomic Energy Held Important in Oil Search

"The recent introduction of atomic instruments in oil exploration has opened up a new geological era," James Mitchel, geophysicist of the Radiac Company, Inc., declared recently. The use of radioactivity detection instruments in oil exploration was an unexpected by-product of aerial surveys for uranium made shortly after World War II by several Canadian "flying physicists," Mitchel reported.

While prospecting for uranium from low-flying aeroplanes, the Canadians used the latest innovation in airborne atomic instrumentation, the Scintillometer, an ultra-sensitive gamma ray detector, which they had developed. Scintillation counting disclosed that almost invariably around the edges of oil fields, there is a "halo" of increased radioactivity. The Scintillometer also revealed that there is less radioactivity directly above the oil fields.

Oil Recovery in Spraberry Ten Per Cent of Potential

The Spraberry Trend of West Texas will not produce more than 10 per cent of the petroleum in its reservoir, unless better recovery methods are developed, William J. Murray told the Centennial of Engineering in Chicago, Illinois, recently. He urged the group of engineers to expand research in oil recovery, stating that the Spraberry field should contain approximately 2,000,000 productive acres when fully developed, compared with 132,000 in the East Texas field, long the world's largest.

Murray said the two things that make any Spraberry production possible are the system of vertical fractures in its rocks and the man-made lateral cracking caused by the Hydrafrac technique. He said the problems confronting production in the Spraberry and the Scurry Reef fields are made more difficult because the force driving the oil into wells in both fields is that of gas dissolved in oil, the least efficient type of drive. This type drive recovers from 10 to 25 per cent of the oil initially in place, compared with 25 to 50 per cent for a gas-cap drive and 50 to 80 per cent for a water drive. A pending unitization plan will increase recovery an estimated 158 per cent, Murray reported.

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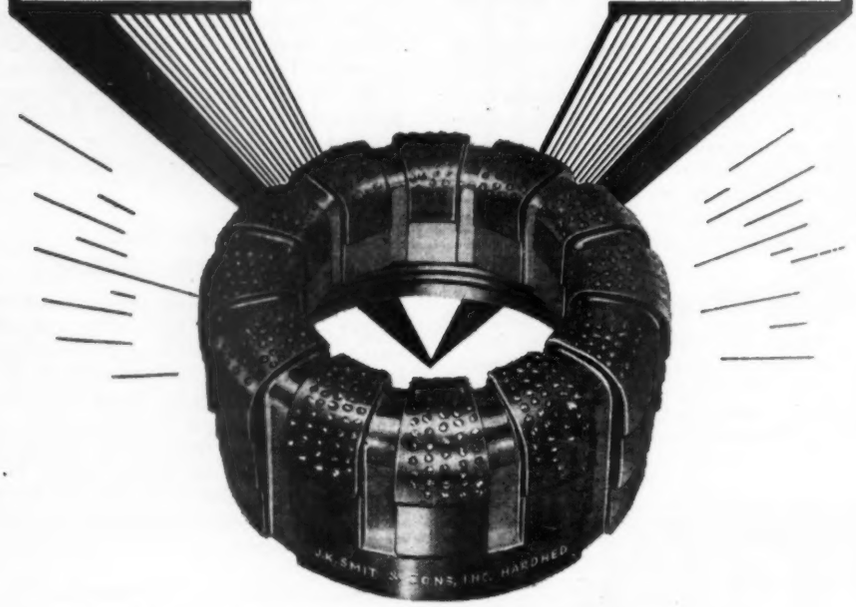

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Gas Flaring Continues, Texas Commission Reports

Continued gas flaring has been noted in the Texas Railroad Commission report for June, which has just been published. The report lists 30 extraction plants flaring more than 2.3 billion cubic feet of gas during the month. Although most of this was dry gas from which liquids had been removed, part was unprocessed wet gas. Total includes all plants where flaring exceeded 2 per cent of the gas handled.

Phillips Petroleum Company's Goldsmith plant in West Texas flared the largest amount during the month, 590,000,000 cu ft. The Commission has restricted production in fields connected with this plant, in an attempt to curtail gas output. An expansion program is underway in the plant, including an increased pipe line outlet for the dry gas from the plant.

Aramco Reports August Oil Output Under July

Crude oil production in Saudi Arabia during August amounted to 25,316,284 bbl, or an average of 816,654 bbl per calendar day, Arabian American Oil Company has reported. This compares with 26,367,901 bbl produced in July, as daily average of 850,577 bbl. Crude oil production for the first eight months of 1952 amounted to 207,948,207 bbl, an average of 852,247 bbl per calendar day.

Mining Exploration Feature Of SEG Canadian Meeting

Mining exploration is the subject for a two day conference of the Society of Exploration Geophysicists being held October 27 and 28 in Toronto, Canada, it was announced by Ralph B. Ross, chairman of the society's Eastern region program committee. Ross, who is assistant director of the geology division, Gulf Research and Development Company, Pittsburgh, Pennsylvania, said that increasing use of geophysical methods in the search for all minerals has prompted the society to sponsor this first meeting devoted mainly to the discussion of mining problems, although some papers on petroleum geophysics will also be presented. The technical sessions will be held in the King Edward Hotel, Toronto.

Ross has appointed W. O. Cartier, consulting engineer with McPhar Geophysics, Ltd., Toronto, as general chairman in charge of arrangements. John Ratcliffe, of Dominion Gulf, and W. Johnson, of Radar Exploration Company, serve with Ross and Cartier on the arrangements committee. Cartier will be assisted also by L. I. Brockway, of Gulf Research and Development Company, president of the Canadian Society of Exploration Geophysicists, Calgary, Alberta chapter of the SEG.

The two full days of technical sessions will allow time for presentation of 18 to 24 papers. A featured paper on exploration for natural gas in Ontario will be "A Gravity Case History: Dawn No. 156, Ontario" by Richard A. Pohly, manager of the gravity division of Seismograph Service Corporation, Tulsa, Oklahoma. In his report, Pohly will describe an Ontario gas pool found by drilling on a "gravity maximum," which is the geophysicists' term for a geologic structure containing materials of greater than average density. This well now supplies natural gas for the people of Chatham, Ontario, and surrounding towns at the rate of 6,500,000 cu ft per day. It is estimated that the pool from which the well is producing contains 13½ billion cubic feet of gas and is situated on one of five Niagaran reefs which have been discovered through gravitational exploration methods in the Southwest Penninsula of Ontario about 50 miles northeast of Detroit and 150 miles west of Toronto.

Test Drilling Begins On Sicily Island

Test drilling has begun in Sicily by American oil interests after four years of exploration produced "convincing" evidence of gas and oil on the Italian island. James Harry MacMillan, director of foreign operations for MacMillan Petroleum of California, reported that Gulf Oil is engaged in preliminary drilling in the Ragusa area of southeastern Sicily, and that the company will also drill a deep test on land controlled by Mediterranean Oil Company, jointly owned by Gulf and MacMillan. The first two wells may go as deep as 12,000 ft, but McMillan reported they had hopes of finding oil at 8000 ft.

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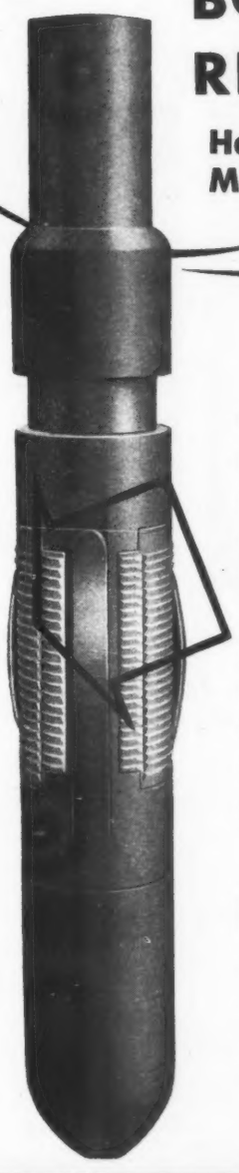

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What's Doing in Drilling

Phillips Deepens Well In West Texas Area

Phillips Petroleum Company is deepening its 12,666 ft well in northeastern Andrews County, West Texas. The No. 1 CC University recovered 1200 ft of free oil on a drillstem test of the Wolfcamp at 10,595-623 ft. On test of the Devonian at 12,513-641 ft the well flowed an unestimated amount of oil. It flowed an estimated rate of 40 bbl of oil an hour for 2½ hr on the second test at 12,541-641. Hole will go to 13,500 ft.

Rotary Rigs Operating in Oil Fields of United States and Canada*

Weeks	Total	Gulf Coast	Pacific Coast	Illinois Oklahoma Kansas	Rocky Mountain Canada	West Texas New Mexico	Arkansas Louisiana Texas	North Texas
(August)								
Fourth	2470	478	160	576	395	464	127	270
(September)								
First	2518	485	157	583	416	470	133	274
Second	2577	512	155	618	430	471	138	253
Third	2582	503	158	621	340	471	136	253

*As reported to the American Association of Oilwell Drilling Contractors by Hughes Tool Company.

Well Flows 601 Bbl Per Day

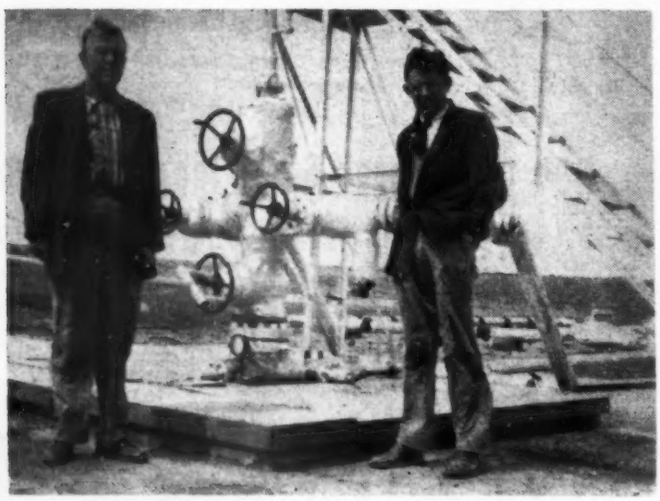
Tide Water Associated Oil Company, Western division, has announced successful completion of its Luton NBR 124 well, Zaca field, California. The new well is pumping at the rate of 601 bbl per day, from a total depth of 5840 ft.

New Sand Zone Indicated

A new sand has been encountered in the West Lincoln field of Lincoln County, Mississippi, Roeser and Pendleton, Inc., have found indications of oil in the Lower Tuscaloosa zone, where the company's No. A-5 Board of Supervisors is preparing to test. The well was cemented at 10,672 ft. Cores taken through the regular producing interval of the field found the sands shaled out. The hole was carried on down to contract depth where an E-log indicated oil sand at 10,604-10 and 10,618-38 ft.

LeBus International Engineers held a meeting in Longview, Texas, recently to discuss spooling of wire rope on drilling rigs. Shown at the party given in the evening are, left, Frank L. LeBus, Sr., and J. T. Carmichael, Brewster, Inc., Shreveport, Louisiana. In another group at the party, seated, Frank L. LeBus, Sr., J. B. Harder, Petroleum Service and Supply, C. A. Maracaibo, Venezuela, E. J. Calk, LeBus, George S. Jackson, Rotary Sales and Service, Ltd., Edmonton, Alberta.

Standing are L. R. Sanders, Broderick and Bascom Rope, Shreveport, and Frank L. LeBus, Jr., Longview.



C. R. Phillips, Shell's drilling superintendent, Canada and Peter Gilpkie, exploitation engineer, at the discovery well of Shell's Jumping Pound field near Calgary, Alberta, Canada.

Hugh A. Wallis, right, is the field superintendent, Far West Oil Company, South Glenrock field, Wyoming, which is on the southern extremity of the Powder River Basin. Hugh has spent a good many years on various oil patches—12 years in Venezuela. He is presently actively engaged in supervising the development of the South Glenrock field. At left is Rex H. Byers, field petroleum engineer. He spent the war years in the American army and was on active duty in Europe.

Fourth Zone Productive In West Texas Field

The fourth productive zone has been opened in the Penwell-Ellenburger field of Ector County, West Texas, with completion of Phillips Petroleum Company's No. 1-B Millard. The new well, producing from the Fusselman, flowed 44 bbl of 43 gravity oil in one hour through a small choke on a drillstem test of the new formation. Depth was 7397-497 ft. The well is being deepened to test the Ellenburger at an estimated depth of 8800 ft.

Palo Pinto Zone Opened

Humble Oil and Refining Company's No. 1-B Mary B. Hall et al has opened production from the Palo Pinto formation in the Harriett field, Tom Green County, Texas. Most production in that area comes from the Strawn at around 4700 ft. The new well flowed naturally from perforations at 4336-52 ft, and has been given a flow potential of 242 bbl of pipe line oil per day through 20/64-in. choke. Oil is 41.3 gravity, with gas-oil ratio of 1100-1. Tubing pressure was 330 lb.

Gas Well Completed In Vernon Pool

A Cleveland sand gas well has been added to the Vernon Pool in Kay County, Oklahoma. New well is Dave Morgan's No. 1 Seipel, which has been completed for 5,000,000 ft of gas daily from perforations at 3047-85 ft.

New Well in Ohio Pool

Wray Drilling Company has a new well in the central part of New Castle pool, Coshocton County, Ohio. The Clinton sand was logged at 3297-3360 ft, with 1,130,000 cu ft of gas and a showing of oil. It was shot with 110 qt, and hole is reported to be filled with oil, with gas drowned out.

Kentucky Field Extended

In Todd County, Kentucky, Stevenson and McGinley's No. 1 Camp is running production tests on the Silurian limestone from 1225-1253 ft, a 1-mile extension of the Herman East pool. Acidized with 1000 gal the well flowed 20 bbl of oil an hour for 4 hr, and then swabbed 5 bbl of oil before being put on the pump.

Oil Well Brought in In Louisiana Gas Field

An oil-producing well has been brought in in the South Pecan Lake area of Cameron Parish, Louisiana, where a large gas-distillate field was opened about a year ago. Pan American Production Company's No. 4 Miami Corporation flowed 498 bbl of 35.8 gravity oil daily on a 12/64-in. choke through casing perforations in the discovery sands at 10,548 to 10,552 ft. Flowing pressure at the new well was 1650 lb and gas-oil ratio was 505-1. Gas-distillate production had been found previously below 12,300 ft.

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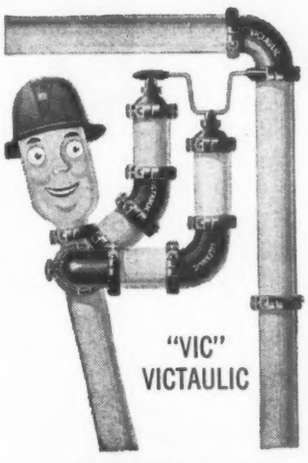

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To obtain more information on products advertised see page E-61

Oklahoma Field Well In Carter County

Kirkpatrick Oil Company has a 25-bbl an hour well in Tatums pool, Carter County, Oklahoma. The Goodwin sand has been perforated at the company's No. 9 Gray-Williams, at 5350 ft. Following treatment the well flowed 25 bbl per hr through 1½-in. choke.

North Dakota Gets 47th Oil Producer

Beaver Lodge Oil Corporation has completed its Math Iverson No. 1-B in Beaver Lodge field, giving North Dakota its 47th producer. Working partners of Beaver Lodge are Tioga Petroleum Corporation and Concord Development. The well is the 37th producer in the Williston Basin. The new well, completed in the Madison formation, is the Williston Basin's 37th producer. It was completed with 480 bbl of 44 gravity oil, no water, flowing to tanks during the first 24 hr of production. Madison formation was topped at 8263 ft.

Spartan Well Successful

Spartan Drilling Company has completed its No. 1 Lovett in the new Spartan pool of San Patricio County, Texas. The well flowed 302 bbl of 36 gravity oil daily through a 10/64-in. choke from 8080 to 8088 ft. Tubing pressure was 1470 lb and gas oil ratio was 741 to 1.

Magnolia Extends Oklahoma Gas-Distillate Field

Magnolia Petroleum Company has extended the East Oklahoma City gas-distillate field in Cleveland County, with completion of its No. 1 Cauthorn. The well was perforated casing at 6737-47 and 6754-64 ft to gage 26,500,000 cu ft of gas a day, with 7 bbl of distillate per hour through a ½-in. choke.

Coppinger Well Added To Hugoton Gas Area

The three-state Hugoton gas area may soon have its first oil well. Tests at W. J. Coppinger No. 1 Beyer in Finney County, Kansas, indicate oil. Nearest oil production is 25 miles away. The well swabbed oil during an 8-hr test at the rate of 80 bbl per hour from 4398-4406 ft. Producing zone is in the Pennsylvanian Marmator lime. It is one of the few wells ever drilled below the Permian gas producing zones of the Hugoton field.

Magnolia Adds New Well To Wayside Oil Field

A new well has been completed in the Wayside field, Adams County, Mississippi, Magnolia Petroleum Company's No. 2 Mable Ellis. The well flowed at the rate of 153 bbl of oil per day through 1/64-in. choke with no formation water present. Completion is from perforations placed opposite the Netterville sand of the Wilcox zone. It was drilled to 6808 ft and cased with 5½-in. pipe to 6690 ft. Tubing pressure was 420 lb and gas-oil ratio 250 to 1.

El Dorado Refining Well Extends Kansas Field

El Dorado Refining Company has a new well in the Edwards North field of Ellsworth County, Kansas. It is the company's No. 1 Andrews, which is being put on the pump. Good production is indicated from the Arbuckle sand, cut at 3301 ft and bottomed at 3305 ft. On a drillstem test at 3302-5 ft, with stem open one hour, 170 ft of clean oil and 30 ft of water were recovered.

Phillips Well Best to Date In Pondera Oil Field

Phillips Petroleum Company has completed the best well to date in the Pondera oil field in Mississippi at its Teton "A" No. 1. The well was completed with an initial flow of 192 bbl of oil daily following 2000-gal acidization. It is ¼ of a mile north of Phillips No. 1 Freda Johnson, which was the original discovery well in this Mississippi district.

New Well Brought in In Leduc Canadian Field

The South Leduc No. 2 well on Crown Reserve holdings in the Leduc oil field in Alberta, Canada, has been completed by Canada Southern Oils, Ltd. On drillstem test the well flowed at the rate of 1200 bbl per day from the D-2 formation at 5324-36 ft of 35 gravity oil.

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Carter Completes 500-Bbl Well in Katie Oil Pool

A 500-bbl per day producer has been added to the Katie pool of Garvin County, Oklahoma, by completion of Carter Oil Company's No. 4 Gibson Estate. On final test, the well flowed 503 bbl of oil and no water in 24 hr through a ¾-in. choke. Flow is from the Gibson sand at 6878-98 ft. Gravity is 39.3 deg corrected, with gas-oil ratio at 735-1. Plugged back depth is 7078 ft, and gas volume is 369,000 cu ft per day.

New Beaver Pool Zone Hit

Gulf Coast Western Oil and Johnson and Gill has completed their No. 1 Tit-Tah for a new sand find in the Beaver pool of Stephens County, Oklahoma. New producing horizon has been identified as the Upper Cisco sand, which was perforated at 6622-56 and 6670-80 ft. It was swabbed and flowed 30 bbl of oil per hour through 2½-in. tubing.

New Well Completed in Cranfield Oil Field

California Company has completed a new well in the Cranfield field of Adams County, Mississippi. It is the company's No. 1 Cranfield Unit 17, which flowed at the rate of 410 bbl of oil and 37 bbl of salt water per day through 13/64-in. choke. Tubing pressure was 1200 lb and gravity of oil 37.6 deg. It was completed from casing perforations opposite the Massive sand at 10,273-92 ft.

Gulf Refining Completes Mississippi Field Well

Gulf Refining Company has completed its No. 3 Crosby Lumber and Manufacturing Company in the Ireland field of Wilkinson County, Mississippi. The well flowed at the rate of 148 bbl of oil per day through a ¼-in. choke, from casing perforations at 6693-97 ft, opposite saturated Wilcox oil sand. Completed at 6725 ft, tubing pressure was 110 lb, gravity of oil 38 deg, and gas-oil ratio was 157 to 1.

Spartan Opens New Oil Flow

New oil production has been opened in the Spartan pool of San Patricio County, Texas, by Spartan Drilling Company. The No. 1 Lovett flowed 302 bbl of 36.7 gravity oil daily through a 10/64-in. choke from 8080 to 8088 ft. Tubing pressure was 1470 lb and gas-oil ratio was 741 to 1.

New Canadian Well Hit Within Export Line Area

The second gas well has been discovered in the Peace River area of Alberta, Canada, 20 miles south of Whitelaw field. It is Imperial Oil, Ltd.'s Belloy No. 2, which tested the Nikanassin formation at 2986 to 3000 ft for gas rated at 6,500,000 cu ft daily. This 3-mile extension to the discovery well will add to the gas reserves at Bellow, within authorized export area for the projected gas export line to the Pacific Northwest.

Shell Adds Elk City Well

Shell Oil Company has added a new producer to the Elk City field in Beckham County, Oklahoma, with completion of its No. 5 McKinzie. The new well flowed from Hoxbar Conglomerate at 581 bbl of oil in 24 hr from perforations at 9752-9890 ft. Gas-oil ratio was 5713-1. Total depth was 10,056 ft.

Bellmont Field Well on Pump

Anderson-Prichard Oil has put its No. 1 Wyatt on pump, on south side of the West Bellmont field of Pottawatomie County, Oklahoma. The Wyatt well showed 102 bbl of oil in 12 hr, from perforations in the Wilcox at 5016-26 ft. Plug-back depth is 5045 ft.

Humble Brings to 12 Number Of Wells in Alabama Field

Humble Oil and Refining Company has completed a new well in the Pollard field, Escambia County, Alabama. It is the company's No. 2 H. D. Finlay, et al, which is flowing at the rate of 101.5 bbl of oil per day through a ⅛-in. choke.

Production is coming from the Pilot sand of the Lower Tuscaloosa perforated at 5965-69 ft. Tubing pressure and casing pressure were 230 lb and gravity of oil 27.8 deg. Gas-oil ratio was reported to be very small.

The well was drilled to 5976 ft, and cased with a 5½-in. pipe to bottom for completion. This brings the number of wells in the Pollard field to 12.

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Exploration Activities

New Discovery Made In San Juan Basin

Stanolind Oil and Gas Company has made an important new disovery in the San Juan Basin of New Mexico, its No. 13 USG. The well tested a total of 15,000,000 cu ft of gas on drillstem tests in the Mississippian from 6886 to 7063 ft. Spray of distillate was reported. The well had tested 13,000,000 cu ft of gas a day on drillstem tests of the Pennsylvania between 6350 and 6538 ft.

Illinois Gets New Well

W. McGuire and Arthur Vandenbark have completed a new producer in Gallatin County, Illinois. It is their No. 1 T. O. Logsdon, which was completed from the Aux Vases sand, 2660 to 2670 ft. On a 24-hr test this well pumped 50 bbl of oil after a 40-qt nitro shot.

Deep Production Hit

The Texas Company has a new deep producer in West Baton Rouge Parish, South Louisiana. It is the company's No. 1 Baist Cooperage and Lumber Company, which was completed to flow 324 bbl of 36.4 gravity oil daily through a 14/64-in. choke, plus 350 bbl of water from 10,155 to 10,176 ft. Tubing pressure was 1450 lb and GOR was 1645 to 1.

Carter Strike Made

Carter Oil Company has a gas-condensate discovery well in Bossier Parish, Louisiana. It is the company's No. 1 Crystal Oil and Refining, which recovered 1080 ft of condensate and 120 ft of drilling fluid from an unidentified sand in the Cotton Valley formation. No estimate has been made of the volume of gas.

Texaco Discovery Completed

The Texas Company has opened a new pool in Dawson County, Montana, with completion of its No. G-1 Northern Pacific Railway No. 4. The well flowed 191 bbl of oil daily through a 20/64-in. choke from the Ordovician formation. Total depth is 10,147 ft.

Arkansas Find Indicated

An important discovery is indicated at Jay Simmons No. 1 Dildy in Miller County, Arkansas. The well flowed clean oil in 35 min on ¾-in. choke at about 250 to 600 bbl a day on drillstem test of sand at 4302-06 ft. Oil was 36 gravity. Flowing tubing pressure was 146 psi.

Best Montana Well Seen

Shell Oil Company is testing what has indicated to be the best well in eastern Montana. It is the company's No. 1 Zuroff, in McCone County. Testing is in the Richey area at about 7200 ft. An earlier test recovered about 1058 bbl of oil per day, along with about 6 per cent of other fluids. The oil is 39 gravity.

Wyoming Field Well Completed by Husky

Completion of a new development well by Husky Oil Company in the Wyoming Grass Creek field, has been announced. Kinney-Coastal No. 10 was successfully tested in the producing Curtis sand. Drilling is progressing satisfactorily in the much discussed step-out in the Five Mile field, near Worland, Wyoming. (Husky-Wilshire) Government No. 1 is drilling below 11,646 ft. Since Husky's discovery in this field (Torgeson No. 1), Sohio Petroleum has moved on to a 9430 ft hole northwest of this discovery well. The Sohio well was drilled by Carter Oil Company in 1947, and shows of gas and oil were logged in the Frontier.

Richfield Completes Second Wheeler Ridge Area Well

Richfield Oil Corporation has completed its second Eocene zone well in the Wheeler Ridge area, 25 miles south of Bakersfield, California, flowing during initial test at the rate of 1900 bbl per day of 35.2 gravity oil through a 24/64-in. bean, 2150 lb tubing pressure.

Top of the Eocene sand was found 180 ft lower than in the discovery well. KCL 76-29 was spudded May 18, and was drilled to a total depth of 10,202 ft, where it was stopped in oil sand. Production is from a 142-ft interval between 10,060 and 10,202 ft. Seven-inch casing was cemented at 10,060 ft, and a 5½-in. liner was landed at 10,200 ft.

This well encountered a shallower productive zone during drilling between 6260 and 6475 ft. After testing at the rate of 1114 bbl a day of 44 gravity oil, the zone was cemented behind casing for later development.

Gas-Condensate Field Gets Multiple Completion

Kerr-McGee Oil Industries, Inc., has reported discovery of a multiple gas-condensate field in Breton Sound, Plaquemines Parish, Louisiana, at its No. 1 C-1 well. Drilled to a total depth of 6880 ft, sand zones were perforated at 4132-36 ft, 4500-5, and 4887-93, and 6729-32 ft. Dry gas was found in the upper three zones. The lower gaged 4,000,000 cu ft of gas and 32 bbl of condensate through a 16/64-in. choke. Total gas of all zones was estimated at more than 100,000,000 cu ft daily.

Louisiana Field Open

Humble Oil and Refining Company has apparently opened a new oil field in the Bayou Chene area of St. Martin Parish, south Louisiana. The well, Humble's W. H. Crowson No. 1 was completed through a ⅛-in. choke for a daily flow of 281 bbl of 37.7 gravity oil. Gas-oil ratio was 576 to 1. Production test was made at 10,691 to 10,696 ft.

Phillips Completes Deepest Producer in Permian Basin

Phillips Petroleum Company has completed the deepest producer in the Permian Basin. The deep well is the No. 1 Glenna in Pecos County, Texas, which was drilled to a total depth of 14,485-14,522 ft. It was completed from the Ellenburger formation, and came in flowing 12,260,000 cu ft of gas plus 3.8 bbl of high gravity condensate. The deep discovery is in an area relatively unexplored in the deep zones. Former deepest well was Magnolia Petroleum Company No. 1 University in Andrews County, which produced from the Ellenburger formation at 13,840-84 ft.

New Strike Indicates Deep Zone in Delaware Basin

Sun Oil Company has a new discovery in Lea County, New Mexico, at its No. 1 Harper et al, which indicates there is an oil structure deeper than the Delaware beds of the Delaware Basin. The showing, which was made in the Lower Leonard, is the first one in this formation of the Delaware Basin. On a drillstem test at 11,665-688, the well recovered 2500 ft of water blanket cut with oil and gas, 3600 ft of 40-gravity oil, and 75 ft of gassy oil-cut mud, together with a blow of sweet gas. Crews are coring ahead.

Discovery Well Opens San Joaquin Valley Pool

A new oil pool discovery has been reported by General Petroleum Corporation, West Coast affiliate of Socony-Vacuum Oil Company, Inc., in the Edison area of San Joaquin Valley, California. Its Graham Fee 42-9 was completed flowing with an initial production rate of 500 bbl daily of 40.3 gravity crude oil, 0.7 per cent cut, with 500,000 cu ft of gas daily through a 16/64-in. choke from 5322 to 5388 ft, and from a lower zone member of the Jewett-Vedder group.

Oklahoma Gets Discovery

The Texas Company and others have a new deep bromide sand oil pool opener in northern McClain County, Oklahoma, at their No. 1 Morehead. The new well flowed 65.2 bbl of 42 gravity oil an hour through ½-in. choke from 8812-62 ft. With Texaco in the venture are Sinclair and Anderson-Prichard.

Large Find Made in Canada

Standard Oil Company of California is reported to have a large discovery in Waskada, Manitoba, Canada. The well, situated on the E. A. McGregor farm, 24 miles east of the Saskatchewan border, is reported to produce 200 bbl daily of "an excellent grade with little water." Drilled by J. Owens Drilling Company, the well was brought in from 3200 ft.

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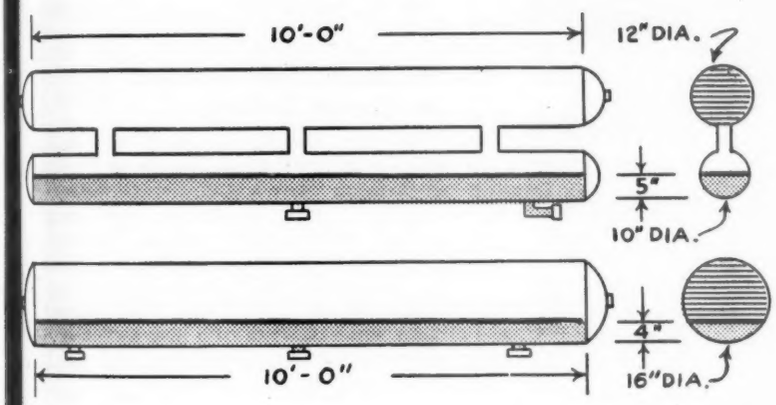

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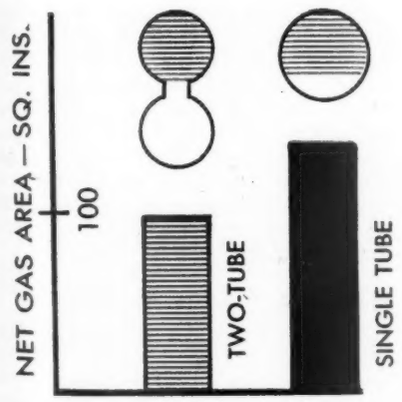
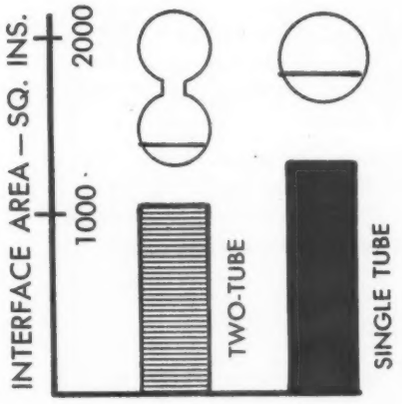
2. Greater Interface Area.
3. Longer Retention Time.

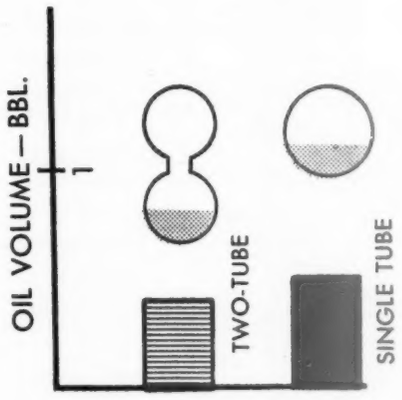
The accompanying drawings and charts, comparing a Parkersburg 16" Single Tube Horizontal Separator with a 12" two tube horizontal separator, clearly indicate how the typical Parkersburg Separator excels in these three factors . . . why it is a far better buy than comparably priced two tube horizontal separators of equal nominal rating.



Greater cross-sectional area for gas flow lowers the velocity of gas, permitting more effective natural separation of the entrained liquid.



Greater interface area allows the oil to attain equilibrium more quickly. Degassing is more thorough and complete . . . foam dissipates more rapidly over the larger interface area.



Longer retention time, resulting from more volume for the liquid allows the oil more time to give up its gas.

5219

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Exploration

Husky Oil Makes Major Discovery in Canada

M. R. McArthur, vice president of Husky Oil Company, Cody, Wyoming, has announced that Gulf CPR Fiveland No. 4 well near Pigeon Lake, Alberta, in which Husky Oil and Refining, Ltd., is a participant, has an oil column of 249 ft. This oil column is overlain by a gas cap of 246 ft. Fiveland No. 4 is a major discovery and not a part of the Bonnie-Glenn field. The top of the producing D-3 was found at 6851 ft and excellent tests have resulted. Phillips Petroleum Company and Standard Oil Company of California also participated in the drilling of this discovery.

Phillips Hits Third Zone In Louisiana Discovery

Phillips Petroleum Corporation has completed a gas-distillate well in Terrebonne Parish, Louisiana, from a third producing sand section. The No. 2 Continental Land and Fur Company was brought in for a calculated open flow from casing perforations of 38,000,000 cu ft of gas daily from perforations at 9372-76 ft, and a calculated open flow of 19,000,000 cu ft of gas at 9240-46 ft, and an open flow of 21,500,000 cu ft of gas daily from 6620-25 ft. Distillate was recovered at the rate of 41 bbl a day through a 2/64-in. choke with the third test.

Standard Announces New East Texas Discovery

Standard Oil Company of Texas has announced a discovery well, Alice Jackson White No. 1, in the Robinson Lake area of Chambers County in East Texas. The well is producing from a Frio sand through perforations in the interval 10,346 to 10,357 ft. Tests established a calculated open flow potential of 25,000,000 cu ft of gas per day, with condensate recovery estimated at 51 bbl per million cubic feet of gas.

Texas Well Completed As Dual Producer

Drilling and Exploration Company's C. C. Gilger No. 1 Emma Bell in San Jacinto County, Texas, has been dually completed, C. A. Wiggins, president, announced. In the first Wilcox sand a gas well was completed at 7810-18 ft of 5,000,000 cu ft open flow with 10 bbl per 1,000,000 cu ft 60 gravity distillate. In the Second Wilcox a new oil zone was discovered at 7850-56 ft, the well producing 245 bbl of 35 gravity oil on a 24 hour test, 12/64 in. choke. The company hopes for a 180 bbl per day allowable on the oil and one-quarter of the open flow on the gas.

Shallow Zone Opened In Garvin County

A new shallow oil pool has been opened by Shell Oil Company at its No. 1 Rose in Garvin County, Oklahoma, northwest of the Robberson field. First proposed as a deep wildcat, the well found its first commercial show of oil at 2715-36 ft, with recovery of heavy black oil on a drillstem test. Second show was 1140 ft of 31.5 gravity oil with a flow of 62,500 cu ft of gas daily on a test at 3649-61 ft.

New Discovery Made In Anadarko Basin

Continental Oil Company is opening an oil pool in the south end of the Anadarko Basin in Caddo County, Oklahoma. New well is Conoco's No. 1 Smith, which pulled a core at 9237-83 ft and got 43 ft of gray shale. During a 3-hr opening in the Marchand sand, gas was estimated at "less than 100,000 cu ft daily" by the company, and 450 ft of oil cut mud that was 25 per cent oil were recovered.

D3 Zone Opens in Alberta

Amerada Petroleum Corporation may have a significant oil strike in northwestern Alberta, about 50 miles east of Grand Prairie. The well is the Crown O-F 33-32, which indicated that commercial production would be found in the D3 zone of Devonian reef formation. The well was drilled to 9000 ft, where it found approximately 90 ft of pay formation. It is being completed at that depth. The discovery is important because finding of production in the D3 Devonian reef zone would open for exploration a large new area about 200 miles northwest of the nearest commercial production from the D3 zone.

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Amerada Opens Fourth Oil Field in North Dakota

North Dakota's fourth oil field was opened recently by Amerada Petroleum Corporation's North Dakota "D" near Charlson in McKenzie County. This well is in the Nesson anticline, as are the other three fields, and is producing from the Madison limestone. The well flowed 127 bbl of 39 gravity oil and 131 bbl of water in 24 hr. In its first production test after completion it flowed 22 bbl of oil and 33 of water in 10 hr.

Kansas Gets 145th Find

Petroleum, Inc.'s, Sandrock South field pool opener in Barton County, Kansas, recently, made Kansas' 145th oil discovery of the year. Pool opener is the No. 1 Tucker A, which drew a state potential of 504 bbl of oil daily from the Kansas City lime formation.

Rank Wildcat Hits Oil in Kansas Test

Stanolind Oil and Gas Company has found oil in a rank wildcat in Finney County, Kansas, its No. 1 Beyer. The well hit the Kansas City lime at 4374 ft, and on a drillstem test from 4374 to 4385 recovered 2250 ft of oil and 3500 ft of gas with a bottom hole pressure of 1260 lb. In the Permian age producing rocks operators estimated the well as good for 15,000,000 cu ft of gas daily. The well is especially important to Kansas, because it proves the potentialities of the state's deepest, thickest, and most extensive deposition. The area covers 25 or more counties in Kansas and is a part of the much deeper Anadarko Basin to the south of Oklahoma.

Texaco Well Completed Flowing 256 Bbl Per Day

The Texas Company has completed a new well in Scurry County, West Texas, its No. 1 M. F. Fuller, a Pennsylvanian reef lime discovery. The well was completed for a daily flowing potential of 256.8 bbl per day of 39.2 gravity oil, plus 92 bbl of basic sediment and water. Production is through a 24/64-in. tubing choke and perforations between 7586 and 7596 ft.

Wyoming Find Successful

Gulf Oil Corporation has a new discovery in Campbell County, Wyoming, at its No. 1 Davis. The well recovered 90 ft of clean 34.3 gravity oil, 90 ft of mud-cut oil, and 90 ft of oil and gas cut mud on a drillstem test between 9775 and 9800 ft. Gas surfaced immediately. The well will go down to 10,000 ft.

Indiana Strike Made

In Gibson County, Indiana, George and Wrather and Aubrey and Tennant Oil companies have completed their No. 1 Anslinger from the O'Hara limestone, at 2025 to 2029 ft. The well was completed for 85 bbl of oil a day on the pump after being acidized with 1500 gal. It is 2 miles from other production and opens a new pool.

Miami Opens Field

Miami Operating Company has opened a new field in Archer County, Texas at its No. 1 Meurer. The wildcat pumped 124 bbl of 44 gravity oil a day from 4486-9 2ft. Total depth of the well is 5105 ft.

Tests Indicate Utah Find

Indications of a new discovery have been found in Continental Oil Company's No. 1 Unit, Unitah County, Utah. The well blew wild for some time, showing natural gas. Gas broke through while drill crews were drilling at 8297 ft. No estimate has been made yet of the volume of gas.

Britco Oils to Survey Canadian Land Holdings

Britco Oils, Ltd., has announced that it has acquired a substantial interest in oil production from the Mic Mac No. 3 well, a D2 producer in the south Leduc field, Canada.

A geophysical survey is being conducted on Britco's wholly-owned 30,000 acres of oil and gas rights in the Duck Mountain Forest Reserve, in the Williston Basin section of southwest Manitoba, adjoining east of acreage now being drilled by Shell Oil Company. Survey contract is being carried out by The Geophysical Prospecting Company, of London, England, and Calgary, Alberta.

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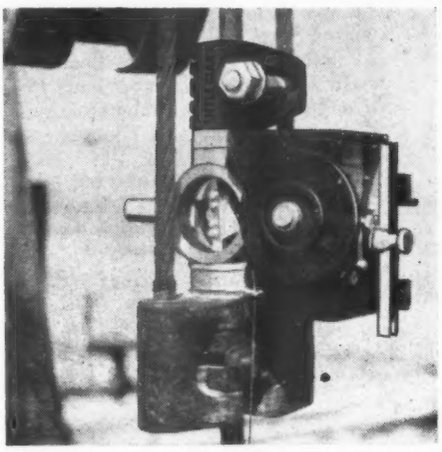

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MARGINAL WELLS

Lifting costs can be *reduced* by closer control and adjustment of mechanical equipment. In one area alone, 25 wells were transferred from red to black by *operational control* with J-F Dynamometer.

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About 80% of all wells checked for counterbalance are found to be out of balance in varying degrees. The J-F Dynamometer measures the counterbalance effect at the polished rod. This enables accurate adjustment for normal pumping operation.

Pulling of "GREEN PUMPS"

Unnecessary pulling of pumps results in extra labor, material costs and downtime. The operations of your pumps may be checked at the surface in a few minutes with a J-F Dynamometer. The test can be made by the foreman, head roustabout or other personnel.

SUCKER RODS

Sucker rod failures are caused by load. The J-F Dynamometer records the load at every point in the stroke so that detailed analysis can be made and corrective measures taken.

EQUIPMENT SIZING AND SELECTION

Based on *facts*, accumulated dynamometer information is extremely useful in selection and installation of proper design and size of equipment.

SIMPLICITY OF OPERATION

The simplicity of operation of the J-F Dynamometer has greatly widened its use for *operational control*. For example, inexperienced personnel, after one day's instruction, can operate the instrument.

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Running Tour With Men in the Industry

William A. Clark has been appointed general manager of the foreign producing department, The Texas Company. Clark, who joined Texaco in 1929 on the Pacific Coast, has been in the foreign producing department since 1947. He is vice president of South American Gulf Oil Company and Colombian Petroleum Company, Texaco affiliates, and vice president of Texas Petroleum Company, a wholly owned subsidiary operating in the Western Hemisphere and West Africa.

J. Harlan Johnson, professor of geology at the Colorado School of Mines, is now in the South Pacific during research work on reef islands under the auspices of the U. S. Army.

He is studying coral reefs, limestones, and reef growths due to lime-secreting sea weeds.

After flying from San Francisco, Johnson set up his research headquarters in Japan, where he will also spend some time visiting Japanese universities and museums before his return to the U. S. in January. Professor at the School of Mines for 32 years, he is on leave of absence for the first semester this year.

His reef studies will take him to the islands of Guam, nearby Rota of the Mariannas group, Truk, Palau, and other small islands in the same area.

Although he working directly under the Army engineers, he will also use the navy and local natives to get specimens from the reefs. Most specimens will come from the shallows, the limestone and reef expert declared before leaving this country, and studies probably are not taking divers more than 25 or 30 ft deep.

John S. Russell, who has been assistant district superintendent of Magnolia Petroleum Company's Falfurrias, Texas, producing district, has been transferred to the Chase, Kansas district. He will be stationed at Kimball, Nebraska, where Magnolia has recently completed three producers and has two wells drilling at the present time.

Henry L. Waszkowski, Jr., formerly assistant district superintendent of the Healdton, Oklahoma, district, has been transferred to the Falfurrias producing district as assistant district superintendent. His headquarters will be at Falfurrias, Texas.

John S. Goodrich, who has been assistant district superintendent of the Pegasus producing district, has been transferred to the Healdton, Oklahoma, producing district as assistant superintendent there.

Cletus H. Samples, formerly a production foreman in the Pegasus district, has been promoted to assistant superintendent of the Pegasus district. His headquarters will be in Midland, Texas.

John C. Fry, driller in Magnolia Petroleum Company's Gulf Coast division, has been promoted to a drilling tools foreman in the Gulf Coast area.

C. I. Warren, assistant land manager, Shell Oil Company, Los Angeles, has been appointed area land manager in Calgary, Canada. Warren began his career with Shell as an oil scout in Oklahoma and has been associated with the company's land department for nearly 25 years.

Concurrent with Warren's transfer, **H. F. Crandall,** division land manager at Bakersfield, goes to the Los Angeles office as area land agent and will act for the land manager in his absence. **C. T. Crewell,** formerly division land manager at Ventura, and presently in Los Angeles on special assignment, will go to Bakersfield to succeed Crandall.

Also, **R. W. Wingo** is being transferred from Canada to Los Angeles as an area land agent to augment the company's expanding land organization.

Dr. R. L. Lupher has been appointed to Shell Oil's Pacific Coast area exploration staff, Los Angeles. Prior to joining Shell in 1945, Dr. Lupher was well known in academic circles. For 14 years he was a member of the faculty of Washington State College at Pullman, Wash., as associate professor of geology.

In 1930 he was awarded his PhD degree in geology and paleontology by the California Institute of Technology.

Raymond A. Williams, Jr., of Dallas, Texas, has been named land manager for the M. B. Rudman oil and real estate holdings. Williams will have headquarters in Dallas and in Denver, Colorado. Before joining Rudman, Williams was a partner in the Dallas law firm of Alexander, George, Russell, and Passman. He is a graduate of New Mexico Military Institute at Roswell, and Southern Methodist University. During World War II, he served in the European and Pacific theaters and was released from active duty at the age of 21 with the rank of Captain.

R. R. McCarty, assistant division superintendent of Humble Oil and Refining Company's Louisiana division, is relieving **J. G. Sloan,** who is absent because of illness.

William Eddis Diamond, rotary driller, was promoted to toolpusher at the Paradis district, Louisiana division.

R. L. Meadows, relief toolpusher, London district, transferred to the North Texas division as toolpusher.

L. B. Parker, senior civil engineer, transferred from the gas construction division to the Clear Lake construction district as district civil engineer.

Maury M. Travis has been transferred to Casper, Wyoming as district geologist, U. S. Geological Survey, Conservation Division, Mineral Classification Branch, Washington, D. C. His new address is P. O. Box 400, Casper, Wyoming.

Clifton S. Corbett, manager of Socony-Vacuum Exploration Company, Calgary, Alberta, Canada, will be transferred to the New York office as advisor to the coordinator of domestic production. **Hiram R. Moorman,** chief geophysicist of Socony-Vacuum, will succeed Corbett. With the recent retirement of Dr. Arthur E. Fath, **Edward C. Cram** will follow Canadian operations along with other duties as assistant to the coordinator of domestic production.

C. H. Broussard

Curtis P. Harkins

A. E. Woerheide, Jr.

C. H. Broussard and **Curtis P. Harkins** have been promoted to vice presidents of Independent Exploration Company. The careers of Broussard and Harkins are remarkably parallel. Each has been with Independent Exploration Company since shortly after leaving school, each began as a helper on a geophysical crew and worked his way up to party chief. After serving as party chiefs, both Broussard and Harkins became geophysicists and were assigned to the general office in Houston. Each has been with the company for 16 years.

A. E. Woerheide, Jr., of Wichita, Kansas, a Shell Oil Company exploitation engineer for 12 years, was named petroleum engineer for Byrd Oil Corporation of Dallas by Colonel D. Harold Byrd, president.

Woerheide joined Shell Oil in 1936 and has been with that company continuously except for four years' service with the Army Corps of Engineers during the war. He received his engineering degree from Missouri School of Mines. He spent the last five years as head of exploitation engineering in Kansas.

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THESE *TEN TOUGH WELLS → X X X X X / X X X X X — HAD A TOTAL PRODUCTION OF 602 BARRELS PER DAY

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*This is a matter of record. All ten wells had been previously perforated with little or no results. Then, they were reperforated by McCullough Glass Jet Perforators — production doubled, tripled, even quadrupled. Other operators have gained a production bonus — **so can you!**

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Houston Nomads' guests recently were: F. B. Allaire, drilling superintendent, CPC, Maracaibo, Venezuela; Kraus Earhart, Texaco, Houston; H. W. R. Wardlaw, Asiatic Petroleum, Houston, Arthur R. Phillips, drilling superintendent, Australasian.

▸ **R. N. Freehling** was advanced to district petroleum engineer at Casper, Wyoming, engineering department, Rocky Mountain division of The Texas Company, replacing **John B. Flugstad,** resigned. In this new position Freehling will be responsible for petroleum engineering activity in Wyoming, northeastern Colorado, and southwest Nebraska.

J. B. Ladd was promoted to the position of district petroleum engineer at Craig, Colorado, and his territory will include northwest Colorado.

Freehling is a graduate of the University of Pittsburgh, Ladd of the University of Kansas.

▸ **Philip L. McLaughlin** has been named drilling editor of *World Oil* magazine, Gulf Publishing Company publication. He was formerly reservoir engineer for Ohio Oil Company in Houston, Texas.

McLaughlin succeeds **W. B. Colvin,** who has been named to a post in training and safety work in Venezuela by Socony-Vacuum de Venezuela. A graduate of the University of Texas, McLaughlin was formerly with Matson and Towne Oil Company, Production Engineering Laboratories, and Continental Oil Company.

▸ **E. W. Price** has joined Kingwood Oil Company as chief geologist in charge of geological and exploratory activities. He was formerly division geologist in Tulsa, Oklahoma, for Stanolind Oil and Gas.

▸ **Harry A. Trueblood, Jr.,** recently announced opening of a new consulting office in Sterling, Colorado, 206 Foote Building. Prior to opening the new office, Trueblood was with California Company in its offshore operations, barge operations, and inland drilling, in Mississippi and Louisiana, and by McDermott and Barnhart in Colorado and West Texas.

▸ **Cortlandt S. Dietler,** division landman for Argo Oil Corporation has resigned. He will return to independent oil operation.

▸ **Millard W. Smith** recently resigned his position as vice president in charge of land and geological department of Anschutz Drilling Company. He will become an independent operator.

Wayne E. Glenn

▸ **Wayne E. Glenn,** Los Angeles, California, petroleum engineer for Continental Oil Company's western region, has been promoted to petroleum engineer for the southern region, with headquarters in Houston, it was announced by H. F. Nabors, southern region production manager.

Glenn joined Conoco in 1943 as a petroleum engineer in New Mexico. He was transferred to company offices in Ponca City, Oklahoma, in 1944 and to Los Angeles three years later.

New Members and induction team at L. A. Nomads group are, standing: J. D. Hughes, Lane-Wells; Floyd C. Cummings, Axelson Manufacturing; Hi Cassidy, The McCarty Company; W. F. Bettis, Johnston Testers. Seated, Thad Randolph, Oil Base, Inc.; Glenn Pitts, Republic Supply; H. J. Hagn, Chiksan; Frank L. Tooley, Baash-Ross Tool; Elmer J. Weis, Pacific Pumps, Inc. Those with signs over their heads are neophytes.

International guests at right, of Los Angeles Nomads September meet are: (Standing back) A. E. Giles, Standard Vaccum, Sumatra; Bud Miles, International Petroleum, Colombia; W. C. Lance and J. O. Donovan, Iraq Petroleum, Iraq; Arthur R. Phillips, Australasian Petroleum, Papua; Larry D. Cannon, Drilling and Exploration, foreign division. Standing forward, E. W. Conn, R. M. Parsons, India; John L. Everett, Mene Grande, Venezuela. Seated, Carlos Osoria, Consul of Chile; Herbert E. Allred of Socony-Vacuum, Venezuela; Harold G. Karnes, Iraq Petroleum, Mosul, and L. E. Miles, Iraq Petroleum, Kirkuk.

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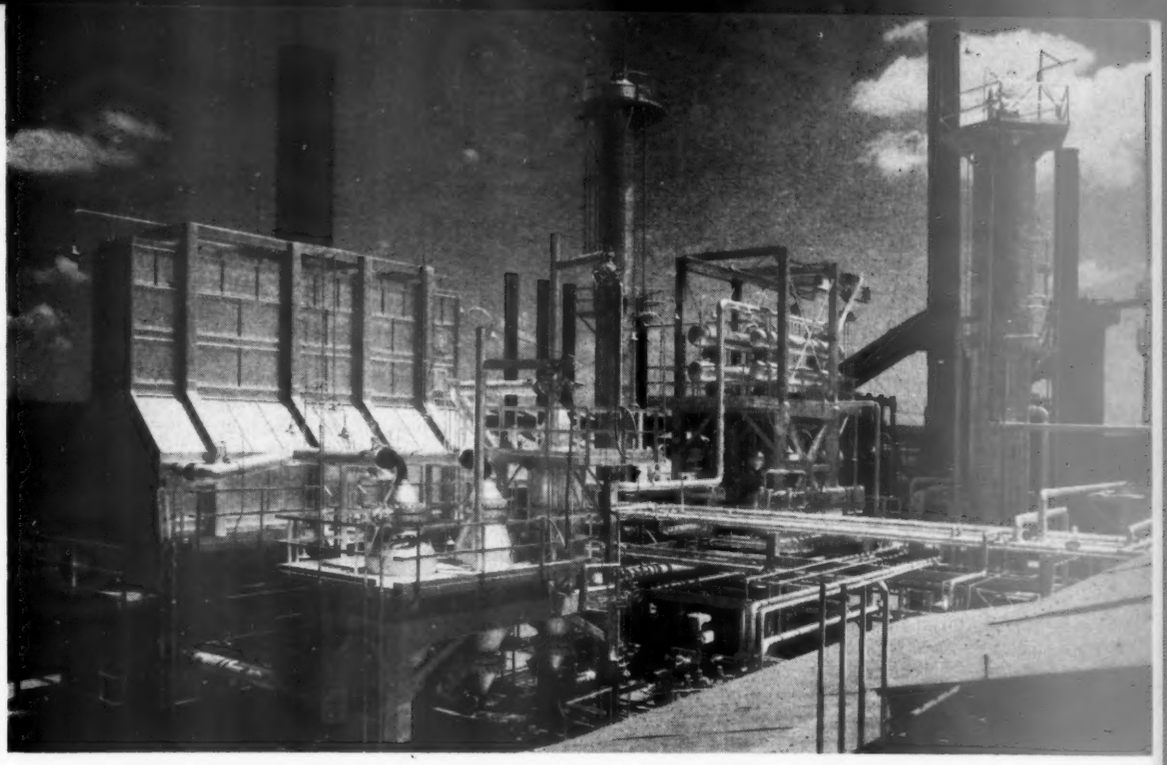

Platformer unit at Johnson Oil Refining Company, Cleveland, Ohio.

Catalysis in Command of Refining

ARCH L. FOSTER*

THE most extensive application of catalysis to manufacturing operations is that of the petroleum industry", E. V. Murphree told petroleum chemists assembled in Atlantic City in mid-September for the 122nd national meeting of the 70,000-strong American Chemical Society. Murphree is head of the tremendous research and development organization, largest in the oil industry, of Standard Oil Development Company. ACS is by far the largest organized aggregation of scientific people on the globe today.

More than 2,600,000 bbl per day of petroleum and its fractions are brought into contact daily with catalysts for conversion to other products with different properties, boiling range, octane ratings, etc., applicable to a multitude of uses. These processes employing catalysts include catalytic cracking, polymerization, alkylation, and catalytic reforming. All rebuild molecules, make bigger molecules from smaller, as in polymerization, or combine dissimilar molecules to build still other molecules, as in alkylation; or do a simultaneous, mainly two-step job of breaking up — "cracking"— large molecules. This is followed by rearrangement of these fragments internally, or recombining them to produce molecular structures possessing properties fitting them for uses for which the original molecules were not suited at all. And the catalysts are the "workhorses" that get these things done — many catalysts of increasing compositional complexity.

*Editor, Refining and Gas Processing.

The future will bring "many improvements" in all these matters, Murphree said. Because of the large quantities of material processes by the refinery units, even small changes result in large financial returns. Among the many jobs waiting to be perfected are the mild hydrogenation of petroleum fractions, to eliminate sulfur and improve stability. An improved hydrogenation operation is needed sadly, to convert heavy residuals, Bunker C fuel oil for example, into lighter products usable for better applications. Already refineries are building additional storage, installing many new units, with the storage to hold excess heavy residual oils neither marketable, as is, nor processable with existing equipment to give salable products. The units are converting heavy oils to useful products, or are avoiding completely the production of these residues in the first place. Some refineries have shut down recently because of overflowing storage.

Catalysts will be applied to conversion of shale oil to petroleum-like commercial and industrial products, the prophecy says. The lighter naphtha fractions that are not converted satisfactorily by present catalytic reforming operations will in the future be treated catalytically to yield higher octane values.

"A knowledge of the mechanism of various catalytic reactions will increase and will expedite the development of improved existing and new catalytic operations," is the prophetic outlook given word by Murphree. "Both old and newer data indicate that future developments in hydrocarbon chemistry are intimately related to a more penetrating analysis of solid state behavior, and its correlation with catalytic activity," said Dr. Hugh S. Taylor, researcher and professor of chemistry at Princeton University, one of our world scientific leaders. Catalytic materials, Taylor says, include metals and those compounds which by reason of defect lattice structures, possess the properties of semi-conductors including hydrides, oxides, sulfides, selenides, and halides of the transition metals.

To judge from the amount of outstanding original research data reported before the petroleum division of the Society, catalysis and the properties, preparation, and utilization of catalysts is far and wide the most important technical or scientific subject in the minds of the refining industry at present. In reviewing the current developments in catalysts and the recent extensions of knowledge of their properties and the mechanism of catalytic reactions, two types of solid catalysts exist, Phillips Petroleum's Alfred Clark pointed out. These are the transition metals—iron, cobalt, nickel, platinum, etc.,—and solid oxide "insulators" such as molybdic oxide, silica, alumina, chromia, etc. The transition metals are used largely for hydrogenation and dehydrogenation reactions. The solid oxide type catalysts promote the reactions of polymerization, alkylation, cracking, and isomerization. These latter are oxides of the lower molecular weight elements in Groups 3,

EXCLUSIVE

4, and 5 in the Periodic Table. So far the most important of these is the combination silica-alumina, employed mainly now for cracking heavy hydrocarbons. "According to recent work," says Clark, "the catalytic activity of silica-alumina is associated with protons located on the catalyst's surface. Dowden postulates that the active centers in the catalysts are protons originating from the residual water that these catalysts always contain and situated at cation vacancies in the oxide lattice." Definite behavior similarities are found between transition metal catalysts, platinum, cobalt, nickel, and the transition oxides of molybdenum, chromium, and tungsten (wolfram). The oxides are weaker, catalytically, needing higher pressures and temperatures to effect the same results as the metals, indicating that the metal ion is the dominant influence in the reactions, and that this explains the lower reactivity of the oxides, which have fewer metal ions not associated with oxygen. A great deal of work has been reported that explains in part and supports these concepts. Metal catalysts in oxidized form, after treatment with air at elevated temperatures show little catalytic activity; after reduction with hydrogen the activity is increased greatly, as much as 50 times in some instances. Alkali addition affects catalytic activity largely in many cases. In butane dehydrogenation over chromia-gel at 932 F the cracking reaction, measured by carbon deposition on the catalyst, allowed only 12-14 hr running cycles. When catalyst is soaked in 2.5 per cent NaOH solution and then used, the running cycle is extended to 55-70 hr by reduction of carbon deposition rate, Clark reported.

By our developed ability to utilize the polyfunctional activities of metal-acidic oxide catalysts, modifying either their physical or chemical properties, we are able to combine in one general catalyst the reactions of isomerization, hydrogenation, dehydrogenation, and dehydrocyclization, Atlantic Refining's Ciapetta, Pitts, and Leum told the chemists' meeting. Research has found that a first-class isomerization catalyst is obtained by combining a hydrogenation agent such as nickel, platinum, or cobalt, with a highsurface area silica-alumina cracking catalyst. Again, Ciapetta has found that by treating a silica-alumina catalyst with steam and/or high temperature methods to reduce its surface area to a value between 10 and 65 sq meters per gram (of catalyst), and depositing on this catalyst quantities of metallic palladium or platinum between 0.01 and 2.5 weight per cent a catalyst is formed that is very *active* and *selective* for dehydrogenating and isomerizing saturated hydrocarbons simultaneously. Houdry Process Corporation has reported development of such a metal-acid oxide catalyst.

Other investigations show that a fresh silica-alumina catalyst alone gives less than 5 per cent conversion of n-hexane to isomers, in the presence of hydrogen at 350 psig. Adding 5 per cent nickel converted 72.6 per cent of the hexane, nearly all of which is isohexanes; nitrogen instead of hydrogen showed little conversion activity. Isomerization is the primary reaction promoted by this catalyst. Use of one-half per cent of platinum gives a catalyst practically equal in activity to the 5 per cent nickel or cobalt-containing catalyst, in achieving isomerization. Iron and copper show very little activity. Thus it is notable that any of the good hydrogenation metal catalysts when combined with silica-alumina produce a good isomerization catalyst. Greater nickel content than 4-6 per cent produces more hydrocracking to lower boiling products; lower nickel content shows decreased catalytic activity.

These catalysts are activated best in hydrogen at 1000 F for 16 hr, lower or higher temperatures giving lower selectivity especially at high conversion rates (80 per cent). Lower temperatures decrease the portion of metal reduced to the metallic state, reducing the activity. Atlantic Refining Company has developed a reforming catalyst of the metal-acidic metal oxide type in which the surface area of the base, silica-alumina, has been reduced by appropriate treatment from 420 sq meters per gram to some lower value, as 22 to 65 sq meters per gram, to permit the use of higher temperatures and to achieve a combination of reactions giving the results we call catalytic reforming. This catalyst is made to give maximum isomer yield, "maximum conversion of cyclohexane to aromatics."

Reaction temperatures for equivalent conversions fall as the molecular weight of the charge increases. N-octane is converted equivalently to n-hexane at 75 F lower temperature; isomerization rates and yields remain the same. With a low surface area silica-alumina, ¼ per cent platinum catalyst (45 m^2/g) at 800 to 950 F and hydrogen at 500 psig, methylcyclopentane is converted 23.7 per cent at 800 F, 78.1 per cent at 950 F, while benzene yield rises from 5.6 to 48.6 per cent through this temperature range.

One of the advantageous reactions of these isomerizing-hydrocracking catalysts is their propensity for hydrogenation in the presence of molecular hydrogen at 300-700 psig, which prevents carbon deposition on the catalyst, maintains its activity over very long periods as compared to straight heavy-oil cracking catalysts, and obviates the need for providing expensive catalyst regenerative equipment. Indications in patent literature are that the UOP Platforming catalyst has increased isomerization properties improved by the formation of "acidic centers" in the alumina by treating it with fluorine or hydrogen fluoride.

Synthetic Fuel Catalysts

In the general synthetic fuels field, Storch of the U. S. Bureau of Mines pointed out that in refining shale oil to produce largely internal combustion engine fuels is a special catalytic processing procedure. Direct conversion of the large amounts of nitrogenous and sulfur-containing impurities to hydrocarbons is a hydrogenation job, including a "hydrogenolysis' step to yield a product suitable for regular refining operations as used on petroleum, Storch stated. Molybdic oxide is one of the hydrogenation catalysts mentioned, and need for better hydro-catalysts exists. Two routes for conversion of shale oil to petroleum-like raw material are outlined; a coking distillation of the crude oil at 1500 psig with a cobalt molybdate-alumina catalyst to give jet and diesel fuels direct, and/or charge stock for catalytic cracking to conventional products. The second route is direct catalytic hydrogenation of the crude shale oil at 200 atmospheres (3000 psig). Only the first method has been carried to an "operable state", and a more selective catalyst is needed, Storch stated.

In hydrogenating coal it has been found that impregnating the coal by immersing or otherwise contacting the coal with a water solution of the catalyst prior to reaction greatly improves the results. Using iron, cobalt, tin, and nickel chlorides and sulfates, research shows that iron and cobalt sulfates are far superior to the chlorides in promoting fluidization of the coal. The chlorides of nickel and tin are superior to the sulfates of these metals in effecting the same essential results, these chlorides showing a few per cent greater conversion than do the sulfates mentioned, (88 per cent compared to 84-85 per cent, respectively). Nitriding of iron catalysts for the Fischer-Tropsch synthesis, from hydrogen and carbon monoxide mixtures, gives more active and more durable catalysts than do the same metals unnitrided. Storch believes that introduction of boron or silicon into the lattice of reduced magnetite (Fe_3O_4), "should yield outstanding changes in selectivity, activity, and durability" of these Fischer-Tropsch catalysts, and that these elements must be added to the reduced magnetite by reaction with a boron or silicon-containing gas.

In developing synthetic fuel processes Storch states that two reactions are of critical importance. One is based on the fact that alcohols that cannot form individual olefins, alcohols such as methyl and benzyl, will react with hydrogen and carbon monoxide to form the alcohol with one more carbon atom. Methyl alcohol forms mainly ethyl alcohol in this way. Benzyl goes one-fourth to phenylethyl alcohol, most of the three-fourths to *toluene*. The second reaction is that the rate of hydroformylation of olefins and alcohols is accelerated by cobalt carbonyl or hydrocarbonyl. These facts point to the "conceivable" design of a process starting with C_1 to C_4 olefins or alcohols and by hydroformylation producing gasoline and diesel fuel boiling range material, with other processing of the higher boiling products.

Space does not permit discussion of the large number (more than 20) other articles on the many petroleum chemistry subjects of major interest to the industry—combustion chamber deposits, spontaneous ignition, analytical procedures, thermal reactions, hydrocarbon synthesis, and several others. Suffice to say that the amount of pertinent, useful data presented was as great as that presented before this body at any time in its history. * * *

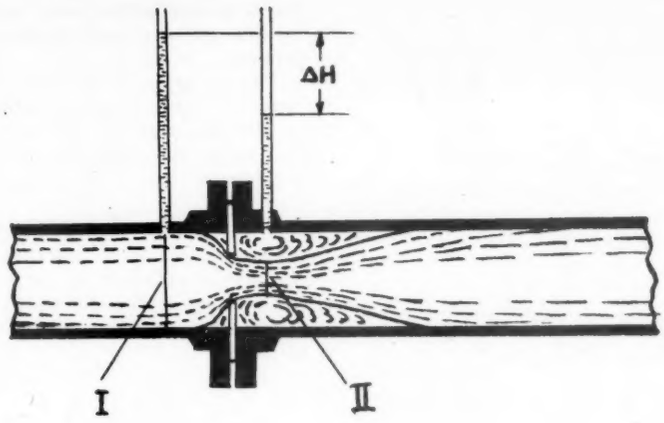

FIG. 1.

Determination of Orifice Meter Coefficients

Detailed formulae and methods for derivation of conversion and corrections factors for orifice meter coefficients

HU SHAO CHIO*

ORIFICES, especially the concentric, thin-plate, square-edged orifices, are by far the most widely used of all the primary elements for rate of flow measurements. In a typical oil refinery or oil field, about 90 per cent of all flow meters in use are orifice meters. It is really an everyday, indispensable tool for petroleum engineers.

When you wish to know the rate of flow from an orifice meter, three things you must learn: (a) the "differential pressure" reading, (b) the so-called "coefficient" of the meter, and (c) an additional "static pressure" reading, in case the flowing fluid is gas.

The differential pressure and the static pressure may be conveniently read from the meter, but the orifice meter coefficient has to be determined through a series of elaborate computations. The value of the coefficient depends upon the shape and size of the orifice plate, the flowing conditions, and the flowing fluid. It is a constant for a given orifice and a given fluid at given temperature and pressure.

When ordering a flow meter, detailed information such as fluid to be handled, service conditions, line sizes, etc., are usually supplied by the user to the meter manufacturer, so the coefficient for that specified fluid and conditions are usually computed by the manufacturer and are stamped on the nameplate of the meter; in that case you simply multiply the square root of the scale or chart reading by the coefficient to obtain the rate of flow.

In case of square-root-chart or scale, the reading itself is the square root, therefore, multiplying the reading by the coefficient gives directly the rate of flow.

If the fluid flowing or the service conditions differ from those of the original design, the coefficient must be recomputed to give exact results.

As was previously stated, it is rather easy to find the rate of flow from an orifice meter provided the coefficient of the meter is already known. If it is necessary, however, to work out a coefficient for a newly installed meter before knowing the rate of flow, in such case, some knowledge of the meaning, the use, and the method of computation of the coefficient is required.

This paper consists of three parts: the first part deals with the basic principles of orifice, the second part deals with the measurement of liquids and the third deals with measurement of gases, especially of natural gas.

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PART 1

Derivation of Base Theoretical Equations

Consider the flow of a fluid through an orifice as shown in Fig. 1, and focus attention on sections 1 and 2. Section 1 is taken as being at a point just before the flow stream starts to converge, i.e., at a sufficient distance upstream from the orifice so that the stream lines of the flowing fluid are parallel to the axis. Section 2 is taken downstream at the point of minimum flow area, i.e., at the "vena contracta," where the stream lines have again become parallel.

Total energy balance over this system is:

$$X_1 + p_1v_1 + \frac{u_1^2}{2g} + E_1 + q + W = X_2 + p_2v_2 + \frac{u_2^2}{2g} + E_2. \quad . \quad . \quad . \quad (1)$$

where:

- X = elevation of fluid above datum line, potential energy of fluid or potential head
- $u_1^2/2g$ = kinetic energy of fluid or velocity head
- pv = work done by the fluid or flow work, pressure head
- W = work done by outside device
- q = heat added to the system from external source
- E = internal energy of fluid
- u = velocity of fluid
- p = static pressure of fluid
- v = specific volume of fluid
- g = acceleration due to gravity

Inscriptions 1 and 2 denote values at Sections 1 and 2.

According to the first law of thermodynamics,

$$q - (E_2 - E_1) = \int_1^2 p\,dv - F$$

where F = friction loss

so eq. (1) becomes:

$$X_1 + p_1v_1 + \frac{u_1^2}{2g} + \int_1^2 p\,dv - F + W = X_2 + p_2v_2 + \frac{u_2^2}{2g} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

which is the mechanical energy balance over Sections 1 and 2 and known as Bernoulli's Theorem.

Since

$$\int_1^2 p\,dv + p_1v_1 - p_2v_2 = -\int_1^2 v\,dp$$

eq. (2) becomes

$$X_1 + \frac{u_1^2}{2g} - \int_1^2 v\,dp + W - F = X_2 + \frac{u_2^2}{2g} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

As the short space between Sections 1 and 2 may be regarded as an isolated system, there can be no energy added from without in any possible form, therefore $W = 0$. Also, assume Sections 1 and 2 are at the same level from the ground line, so $X_1 = X_2$. The frictional force between the two sections may be assumed for the moment to be negligible and later corrected by an over-all factor, so $F = 0$. Equation (3) then becomes:

$$\frac{u_2^2 - u_1^2}{2g} = -\int_1^2 v\,dp \quad . \quad . \quad (4)$$

Again, assume the fluid is of constant density at 1 and 2. With a liquid this is true; with a gas, however, there is a slight error here that we will correct later by the use of an expansion factor. Equation (4) may be then written in the form:

$$\frac{u_2^2 - u_1^2}{2g} = (p_1 - p_2)\,v \quad . \quad . \quad (5)$$

Which means that the work done by the fluid between these two points is equal to the change in kinetic energy.

If the flowing fluid is a liquid and we connect a gage glass at 1 and another at 2, the height of the liquid column risen in the glass at 1 is pv and at 2 is p_2v, the mathematics of this consideration is not changed by using a gas as flowing fluid.

Let the difference in height of the two liquid columns be ΔH

$$\Delta H = p_1 v - p_2 v$$

we have

$$u_2^2 - u_1^2 = 2g\Delta H \quad . \quad . \quad . \quad . \quad . \quad (6)$$

in which

ΔH = differential pressure or pressure loss across the orifice plate at point of pressure measurement, expressed in feet head of flowing fluid.

Equation (6) is known as the Hydraulic Formula.

In order to apply Equation (6), we must know the diameter of vena contracta, which is variable and impossible to determine. The relation between area of vena contracta and area of orifice depends upon many factors, such as pattern of flow, ratio of orifice diameter to pipe diameter, etc., therefore we have to use the orifice diameter instead of vena contracta diameter and later correcting for the relation of the two as a part of an efficiency factor.

Let u_0 = velocity of fluid at the orifice.

Use u_0 to replace u_2 in Equation (6), we obtain

$$\sqrt{u_0^2 - u_1^2} = C_v\sqrt{2g\,\Delta H}. \quad (7)$$

where:

C_v = a factor to compensate the effect for vena contracta.

Since

$$\frac{u_0}{u_1} = \frac{A_1}{A_0} = \frac{D^2}{d^2}, \quad \therefore u_1 = \left(\frac{d^2}{D^2}\right)u_0$$

where:

d = diam. of orifice bore
D = internal diam. of pipe
A_1 = cross sectional area of pipe
A_0 = actual orifice area

substitute u_1 in (7),

$$\sqrt{u_0^2\left(1 - \frac{d^4}{D^4}\right)} = C_v\sqrt{2g\,\Delta H}$$

The ratio of d/D is usually denoted by β, the factor $1/(1-\beta^4)^{1/2}$ is called velocity of approach factor.

Let C_a = velocity of approach factor, then

$$u_0 = C_v\,C_a\sqrt{2g\,\Delta H}. \quad . \quad (8)$$

Because there are also turbulences in the flow pattern, which cause internal and external friction, we add a third factor C_t to cover these effects.

$$\therefore u_0 = C_v\,C_a\,C_t\sqrt{2g\,\Delta H} \quad (9)$$

in which

C_v = effect of vena contracta
C_a = velocity of approach factor
C_t = effect of turbulence

These three factors are combined into a single factor E, called "coefficient of discharge," or "efficiency" of the orifice, the value of which must be determined by experimental work.

Rewrite Equation (9) into a more general form:

$$u = E\sqrt{2g\,\Delta H} \quad . \quad . \quad (10)$$

Which is the basic formula for fluid flow through an orifice. Multiply Eq. (10) by time and area factors, which gives volume rate of flow.

Since

$$V = u_1A_1 = u_0A_0,$$

$$V = E\,A_0\sqrt{2g\,\Delta H} \quad . \quad (11)$$

where V = volume of fluid passing through orifice per unit time.

Equation (11) is the basic formula for orifice measurement, which states that the rate of flow for any given orifice and pipe is proportional to the square root of the head of pressure loss across the orifice plate. This is the basic principle of all orifice meters.

PART 2

Liquid Measurements

Liquids are practically incompressible, therefore no important effect of static pressure variation is involved in the measurement of liquid with orifice meters. The static pressure recording system is not required on a liquid flow meter as on a gas flow meter. This fact simplifies the calculation of the coefficient to some extent, since no correction for base pressure and expansion effect is needed.

The variation in viscosity of a liquid, however, offers a very troublesome factor that introduces much more complication in the determination of liquid flow coefficients than it does in gas work.

General Equation

In practical work, the rate of flow of a liquid is obtained by multiplying the square root of the differential pressure or head loss in inches of water, by a coefficient,

$$Q = C''\sqrt{h} \quad . \quad . \quad (12)$$

where

Q = rate of flow
C″ = an over-all orifice flow coefficient
h = differential pressure as registered by the meter, calibrated in inches of water

The coefficient C″ comprises all factors that will effect the true flow measurement. It is composed of many terms of individual constants and correction factors, each corresponding to a single effect respectively. The combined result is a multiplier C″ used to obtain the actual flow rate. It is really the quantity of liquid that flows through the orifice during unit time when the differential pressure is 1 in. of water.

$$C'' = N \times F_b' \times F_s \times F_t \times F_g \times F_e \times F_r \quad . \quad . \quad . \quad (13)$$

in which

N = unit conversion factor, a constant depending on the unit by which Q is expressed
F_b' = basic factor of orifice for liquid flow = $327.421Ed^2$
F_s = correction factor for weight of liquid above manometer mercury (seal liquid)
F_t = correction factor for variation in density of liquid with temperature.
F_g = correction factor for specific gravity of the liquid
F_e = correction factor for thermal expansion of primary element
F_r = correction factor for viscosity or Reynolds No.

These factors will be discussed one by one in later sections.

Derivation of Basic Practical Equation for Liquids

In deriving the practical flow formula we arrived at the fundamental equation

$$V = E\,A_0\sqrt{2g\,\Delta H} \quad . \quad (11)$$

In practical work, we usually wish to express the rate of flow in gallons per hour, and the head not in feet of the flowing fluid, but equivalent inches of water.

Since
1 cu ft = 7.4805 gal
g = 32.17 ft/sec/sec
$\Delta H = \Delta h/12$
substituting all known values in eq. (11)

$$V = EA_o\sqrt{2g\,\Delta H}$$

$$= E\frac{\pi\left(\frac{d}{12}\right)^2}{4} \times \sqrt{2g\,\Delta H}$$

$$= E\left(\frac{\pi d^2 \times 3600 \times 7.4805}{4 \times 144}\right) \times \left(\sqrt{2 \times 32.17} \times \sqrt{\frac{\Delta h}{12}}\right)$$

or

$$V = 340\ E\ d^2\sqrt{\Delta h}$$

where
V = rate of flow in gallons per hour
E = efficiency factor
d = diameter of orifice in inches
Δh = differential head in inches of flowing fluid

Since

$$\Delta h = \frac{h'}{G_f}$$

where
h′ = differential head converted to inches of water, with air on surface of mercury
G_f = sp gr of flowing liquid at flowing temperature, (water at 60 F = 1)

$$\therefore V = 340\ E\ d^2\sqrt{\frac{h'}{G_f}}. \quad (14)$$

Correction for Weight of Fluid Above Manometer Mercury

In actual case, the differential head is the reading of Hg manometer converted to inches of water. When mercury in the manometer gage is displaced, the liquid displacing it adds to the differential existing at the orifice an amount equal to the head between the upper (low pressure chamber) and lower (high pressure chamber) surface of the displaced mercury. See Fig. 2.

$$h = h' + h\frac{G_s}{G_m}$$

$$\therefore h' = G_f\,\Delta h = h\left(\frac{G_m - G_s}{G_m}\right)$$

$$= h\left(\frac{13.557 - G_s}{13.557}\right)$$

where
h = gage or chart reading calibrated to inches of water at 60 F, with liquid above Hg surface
G_s = sp gr of liquid displacing Hg, (water at 60 F = 1)
G_m = sp gr of Hg = 13.557 (water at 60 F = 1)
Substitute h′ for h in (14)

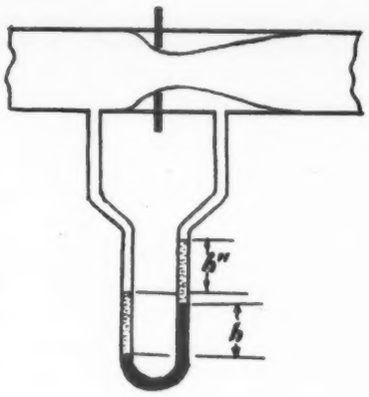


FIG. 2.

$$V = 340\ E\ d^2\sqrt{\frac{13.557 - G_s}{13.557}} \times \sqrt{\frac{h}{G_f}}. \quad (15)$$

Let F_s = correction factor for weight of liquid above Hg.

For convenience, it is desirable to arrange the constant and correction factor F_s in Equation (13), so that if water at 60 F is used as displacing liquid, the factor F_s equals to 1
so we can write

$$F_s = \sqrt{\frac{13.557 - G_s}{13.557}} \times \sqrt{\frac{13.557}{13.557 - 1}}$$

$$= \sqrt{\frac{13.557 - G_s}{12.557}} \quad (16)$$

Note that in above formula if G_s = 1, F_s = 1.

As we have modified the seal correction factor to give a value of 1 for water, we must modify Equation (15) to equality by multiplying Equation (15) with the reciprocal value of the factor, i.e., $(12.557/13.557)^{1/2}$

$$\therefore V = 340 \times \sqrt{\frac{12.557}{13.557}} \times Ed^2 \times F_s \times \sqrt{\frac{h}{G_f}} = 327.421\ Ed^2\ F_s\sqrt{\frac{h}{G_f}} \quad (17)$$

If the liquid seal is not used, the flowing liquid becomes displacing liquid and G_b, specific gravity of flowing liquid at 60 F, is used instead of G_s in computing the value of F_s by Equation (16). The manometer fluid is always assumed to be at an average temperature of 60 F.

The differential head between the seal liquid and flowing liquid (h″ in Fig. 2) is so small that it may be neglected safely.

Basic Orifice Factor F'_b

Let us consider a simplest case as an example for applying Equation (7): The rate of flow of water at 60 F through an orifice.
As

$$G_f = 1,\ G_b = G_s = 1,\ F_s = 1$$

Equation (17) becomes

$$V = 327.421\ E\ d^2\sqrt{h} \quad (18)$$

The factor $327.421Ed^2$ is called the basic orifice factor for liquid measurement or F'_b, which is obtained under assumptions

1. that the rate of flow is expressed in gallons per hour
2. that the differential head is in inches of water
3. that the sp gr of flowing liquid at 60 F = 1
4. that the flowing temperature is 60 F
5. that no liquid seal is used in manometer

If any of the actual conditions vary from the above assumptions, a corresponding correction factor must be added to the basic factor.

Unit Conversion Factor N

When it is desirable to express the rate of flow in some other units, such as barrels per day or gallons per minute, the constant N is used to convert gallons per hour to desired unit.
N = 1 for gal per hour
N = 0.0167 for gal per min
N = 0.572 for bbl per day
If we want to express the rate of flow in weight per unit time such as pounds per hour or tons per day, then a gravity conversion factor must be included in N.

$$N = \frac{62.4}{7.48} \times G_b =$$

$8.33\ G_b$ for lb per hour

$$N = \frac{62.4 \times 24}{7.48 \times 2000} \times G_b$$

$= 0.01\ G_b$ for short tons per day in which
G_b = sp gr of flowing liquid at 60 F.

Efficiency Factor E

Since basic flow Equation (10) is derived from theoretical flow conditions, the result obtained from this equation somewhat deviates from actual flow. The compensating factor to correct from theoretical flow to actual flow is called the efficiency of orifice E, which is indeed the ratio of actual flow to hypothetical flow. The exact value of E must be experimentally determined, but if experimental data are not available, the following empirical formula may be used to give approximate values of E.

$$E = 0.598 + 0.01\left(\frac{d}{D}\right) + 0.00001947\left(\frac{10\,d}{D}\right)^{4.425}$$

(for flange tap only)

Explanation of E given in Part 3.

Correction for Variation in Specific Gravity of Flowing Liquid with Temperature

The density or specific gravity of flowing liquid varies with change of temperature, thus influences considerably the manometer reading. If hot liquid is flowing through the orifice the liquid density

must be corrected to base temperature 60 F to give checked results.

Let

F_z = expansion ratio, ratio of specific gravity of liquid at flowing temperature to its specific gravity at 60 F

$$F_z = \frac{G_f}{G_b}$$

where

G_f = specific gravity of liquid at flowing temperature (when water at 60 F = 1)

G_b = specific gravity of liquid at base temperature 60 F (water at 60 F = 1)

Substituting $G_b F_z$ for G_f in Equation (17)

$$V = 327.421\ E\ d^2\ F_s \frac{1}{\sqrt{G_b F_z}} \sqrt{h} \quad . \quad (19)$$

Correction for Volume of Flowing Liquid at Base Temperature

It is general practice to express the final result in volume of flowing liquid as if at the storage temperature, but storage temperature is lower than flowing temperature, therefore a correction for shrinkage in volume must be involved. Usually tank gages are corrected to volume at 60 F, so rate of flow must correct to same temperature in order to check well.

Multiply Equation (19) with F_z,

$$V = 327.421\ Ed^2\ F_s \sqrt{F_z} \sqrt{\frac{1}{G_b}} \sqrt{h}$$

let

$$F_t = \sqrt{F_z} = \sqrt{\frac{G_f}{G_b}}, \text{ and } F_g = \sqrt{\frac{1}{G_b}}$$

then

$$V = 327.421\ E\ d^2\ F_s\ F_t\ F_g \sqrt{h} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (20)$$

where

F_t = temperature correction factor, factor to correct for variation in density of flowing liquid with temperature.

F_g = gravity correction factor, factor to correct specific gravity of flowing liquid.

G_b and G_f data may be found from handbooks or calculated from physical data of reference books. If they are not available, they must be obtained by direct determination.

If F_t is not used, V in Equation (20) will represent the rate of flow of liquid at temperature prevailing at the orifice.

Correction for Thermal Expansion of Primary Element

The value of d (orifice diameter) and D (pipe diameter) that we know are measured at atmospheric temperature, but all equations in the above are based on d and D at flowing temperature, therefore a factor to correct for expansion of the primary element must be introduced in the flow coefficient for high temperature service.

Because the bore of the orifice plate is the predominant factor, the error introduced by assuming that the pipe expands at the same rate as the orifice is negligible.

Let

F_e = correction factor for thermal expansion of orifice plate, the value of which depends upon the thermal expansion characteristics of the orifice plate material.

$$F_e = \frac{d'^2}{d^2}$$

in which

d' = orifice diameter at flowing temperature t F (actual diameter)

d = orifice diameter at atmospheric temperature (rated diameter)

and

$$d' = d\ (1 + \alpha t)$$

where

α = coefficient of linear expansion of orifice plate material, inches per ° F; it may be found from handbooks.

Equation (20) should now be written as:

$$V = 327.421\ E\ d^2\ F_s\ F_t\ F_g\ F_e \sqrt{h} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (21)$$

Correction for Viscosity or Reynolds Number

The viscosity of liquid has a remarkable effect on the flow through orifices. In determination of flow coefficient, the variation of viscosity offers a very troublesome factor.

Experimental work indicates that the flow coefficient bears a direct relation to Reynolds Number, which is defined as follows:

$$Re = \frac{d''\ u\ \rho}{\mu}$$

where

Re = Reynolds Number based on orifice conditions.

d'' = orifice diameter in feet at flowing temperature.

u = velocity of flowing fluid at orifice in feet per second.

ρ = density of flowing fluid at orifice condition, pounds per cubic feet.

μ = absolute viscosity of flowing fluid, English unit, pound per foot second at flowing temperature.

No matter how the numerical values of the four factors d'', u, ρ and μ vary, if they combine in the form of $d''u\rho/\mu$ and give the same value of Re, the flow coefficient will be the same.

Let

V' = actual rate of flow, gallons per hour at flowing temperature.

μ' = kinetic viscosity of liquid in Saybolt Universal Seconds at flowing temperature.

u' = velocity of flowing liquid in feet per hour.

μ'' = absolute viscosity of liquid in centipoises at flowing temperature.

then

$$\frac{V'}{d'\ \mu'} = \frac{\frac{\pi}{4}\left(\frac{d'}{12}\right)^2 u' \times 7.48}{d' \times \frac{4.65}{G_f} \times \mu''}$$

$$= \frac{\pi \times 7.48}{144 \times 4 \times 4.65} \times \frac{d'\ u'\ G_f}{\mu''}$$

and

$$Re = \frac{\left(\frac{d}{12}\right) \times \left(\frac{u'}{3600}\right) \times G_f \times 62.4}{0.00672 \times \mu''}$$

$$= \frac{62.4}{12 \times 3600 \times 0.00672} \times \frac{d'\ u'\ G_f}{\mu''}$$

$$\therefore Re = \left(\frac{62.4 \times 144 \times 4 \times 4.65}{12 \times 3600 \times 0.00672 \times \pi \times 7.48}\right) \times \frac{V'}{d'\ \mu'} = 245.2 \times \frac{V'}{d'\ \mu'}$$

where

G_f = specific gravity of liquid at flowing temperature (water at 60 F being 1)

d' = orifice diameter in inches at flowing temperature.

Note: Kinetic viscosity in S.U. S. $\simeq \frac{4.65}{G_f} \times$ absolute viscosity in centipoises (when SUS $>$ 190)

1 centipoise = 0.00672 English units, (lb/ft sec)

Let

V'' = rate of flow in gph, computed from non-viscous flow equation, reduced to flowing temperature, or called indicated gallons per hour.

then

$$V'' = V \times \frac{G_b}{G_f} = \frac{V}{F_t^2}$$

in which V = rate of flow as calculated from Equation (21)

but

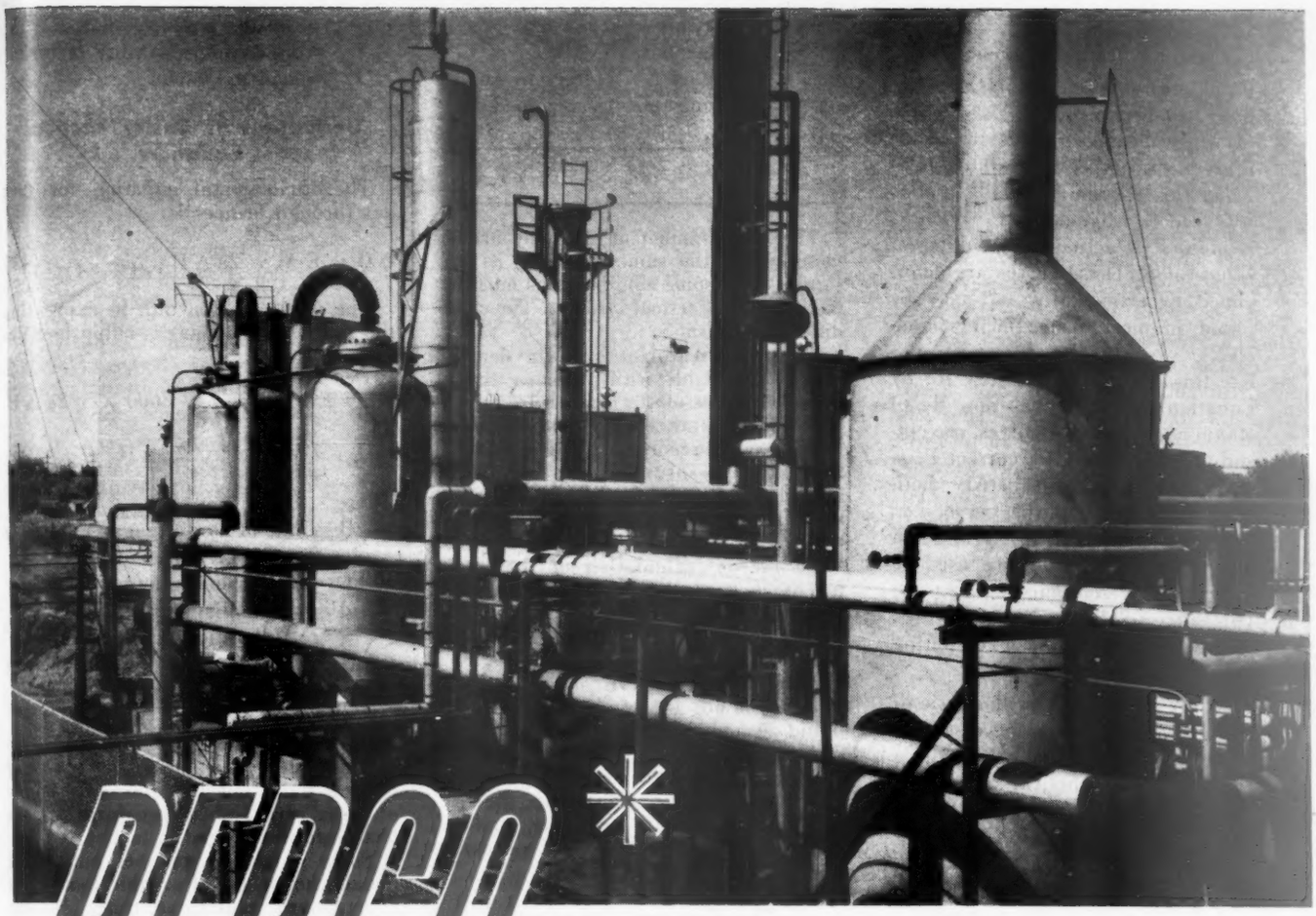
$$V' = V'' \times F_r, \text{ also } d' = \sqrt{F_e}\ d$$

where

F_r = Reynolds Number correction factor.

F_e = correction factor for thermal expansion of orifice.

$$\therefore Re = 245.2 \times \frac{V''}{d'\ \mu'} \times F_r = 245.2 \times \frac{V}{F_t^2 \times \sqrt{F_e} \times d\ \mu'} \times F_r \quad . \quad (22)$$



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Steps to determine F_r:

1. Calculate V from Equation (21).
2. Calculate the value of $V/(F_t^2 \sqrt{F_e}\, d\,\mu')$ from known data.
3. Multiply the above value by 245.2; it gives a hypothetical Re number.
4. From this Re and β (ratio of d to D), read F_r from curves in which F_r is plotted vs. actual Re, at different values of β. These curves are determined experimentally and may be found in most orifice meter handbooks.
5. Use this F_r to obtain a new Re by Equation (22), use this new Re to obtain a new F_r from curves, use cut-and-try method until a correct F_r is obtained, which will satisfy both Equation (22) and the curve, i.e., the Re as calculated from Equation (22) agrees with the Re used to determine F_r from curve.
6. This correct value of F_r should then be used as a multiplier in computing flow by Equation (12).

F_r usually are plotted on the basis of actual flow, therefore it is necessary to use a cut-and-try method to obtain a correct F_r from hypothetical data (without involving viscosity factor). But if F_r are plotted on the basis of hypothetical flow, i.e., F_r vs. $V''/(d\,\mu')$ or indicated $gph/d\,\mu'$ (as shown in "Principles and Practice of Flowmetering," by Spink) the curves will appear "warped" when compared with experimental data, and because of this "warping," they may be applied without the troublesome cut-and-try procedure.

If the value $V''/d\,\mu'$ is more than 332, F_r may be safely neglected.

Summary

The rate of flow of liquid can be computed from the following formula:

$$Q = C'' \sqrt{h}$$

in which

- h = scale or chart reading of the differential head of the meter, in inches of water.
- C'' = a multiplier called orifice flow coefficient.

The value of C'' should be calculated from the following equation:

$$C'' = N\, F'_b\, F_s\, F_t\, F_g\, F_e\, F_r$$

where

- N = unit conversion factor, if Q is in gph, $N = 1$.
- F'_b = basic factor $= 327.421 Ed^2$.
- F_s = seal liquid correction factor $= \sqrt{\dfrac{13.557 - G_s}{12.557}}$
- F_t = temperature correction factor $= \sqrt{G_f/G_b}$.
- F_g = gravity correction factor $= \sqrt{1/G_b}$.
- F_e = orifice plate expansion correction factor $= d'^2/d^2$.
- F_r = Reynolds No. correction factor, experimentally determined.

PART 3

The measurement of gases by orifice meter is by the same principle as for liquids, only some modifications must be made in the practical formula. The chief difference exists in:

A. Static Pressure—Since the density of gas is variable with pressure, therefore, the effect of static pressure variation must be taken into consideration. In making the record on the meter chart, the static pressure pen must be added, and the practical formula contains a static pressure multiplier in addition to the differential head multiplier. For the same reason, calculation of the coefficient is somewhat more complicated than in liquid, some extra correction, such as base pressure factor, expansion factor must be added.

B. Viscosity—The viscosity factor of gas flow is not as significant as that of liquid flow due to low density of gas. Only at extremely low gas rates do the viscosity effects become sources of inaccuracy. For natural gas work, the viscosity does not vary seriously, and is assumed to be constant for all measurements.

The General Equation

Gas flow measurement by orifice meter consists of recording two variables, the static pressure and the differential head. The rate of flow is the square root of the product of these two variables multiplied by a "coefficient."

$$Q = C' \sqrt{h} \sqrt{P_f} \quad . \quad . \quad . \quad . \quad (23)$$

where

- Q = rate of flow of gas.
- h = differential head.
- P_f = absolute static pressure of gas.
- C' = an over-all orifice flow coefficient.

The coefficient C' consists of several combined products of constants and correction factors. The identification of correction factors is different based on different considerations and derivations. There have been two kinds of formulas. One is based on American Gas Association Committee Report No. 1, the other is based on AGA Committee Report No. 2. No. 1 report is older and simpler but less accurate while No. 2 report is more accurate and up-to-date. From No. 2 Report, the coefficient

$$C' = F_b\, F_r\, Y\, F_{pb}\, F_{tb}\, F_{tf}\, F_g\, F_{pv}\, F_m$$
$$. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (24)$$

where

- F_b = a basic factor $= 345.92\ Ed^2$.
- F_r = Reynolds Number factor.
- Y = expansion factor.
- F_{tb} = temperature base factor.
- F_{tf} = flow temperature factor.
- F_{pb} = pressure base factor.
- F_g = specific gravity factor.
- F_{pv} = supercompressibility factor.
- F_m = moisture factor.

Derivation of Basic Practical Equation

The fundamental equation for flow gas through orifices is:

$$Q = E\, A_o \sqrt{2g\, \Delta H} \quad . \quad . \quad . \quad . \quad (11)$$

The most common unit in expressing the rate of flow of gas is cubic feet per hour, so

$$Q = E \times \frac{\pi}{4} \times \frac{d^2}{144} \times 3600 \times \sqrt{2g\, \Delta H}$$

$$Q = 19.64\, E\, d^2 \sqrt{2g\, \Delta H} \quad . \quad . \quad (25)$$

where

- Q = rate of flow of gas in cubic feet per hour.
- E = an efficiency factor.
- d = orifice diameter in inches.
- g = acceleration due to gravity.
- ΔH = differential pressure in feet head of flowing fluid.
- A_o = area of orifice in square feet.

In practical work, we also express the differential pressure head not in feet of flowing fluid, but in equivalent inches of water, so we must transform the gas head into water head in inches.

Since weight of gas per cubic foot equals the weight of a cubic foot of air at standard conditions times specific gravity of the gas with respect to air,

$$\therefore \Delta H = \frac{h}{12} \times \frac{\rho_w}{\rho_a \times G} = \frac{h}{12} \times \frac{62.37}{0.08073 \times G}$$

where

- h = diff. head in inches of water.
- ρ_w = 62.37 = density of water at 60 F.
- ρ_a = 0.08073 density of air at S.T.P. (Standard Temperature and Pressure).
- G = specific gravity of gas relative to air at S.T.P.

It should be noted that gas density was taken at S.T.P., i.e., 32 F and 14.7 pound per in.,^{2} absolute pressure. Assume that the gas obey Boyle's Law and Charles' Law, i.e., the density of gas varies directly with absolute pressure and inversely with temperature.

Let

- P_f = absolute pressure of flowing gas.
- T_f = absolute temperature of flowing gas.
- ρ = density of gas at flowing condition.

then

$$\rho = \rho_a \times G \times \frac{P_f}{14.7} \times \frac{492}{T_f}$$

$$\therefore \Delta H = \frac{h}{12} \times \frac{62.37}{0.08073 \times G} \times \frac{14.7}{P_f} \times \frac{T_f}{492}$$

substitute these values for ΔH in Equation (25) and take "g" as 32.17

$$Q = 19.64\ E\ d^2 \sqrt{2 \times 32.17 \times \frac{h}{12} \times \frac{62.37}{0.08073 \times G} \times \frac{14.7}{P_f} \times \frac{T_f}{492}}$$

$$Q = 218.44 E d^2 \sqrt{\frac{h\,T_f}{P_f\,G}} \quad . \quad (26)$$

Now the Q is in cubic feet of gas of specific gravity G at absolute pressure P_f and absolute temperature T_f. Usually in gas work, when we speak of cubic feet of gas, we must specify at what pressure base and temperature base we wish to express the volume. Therefore the above value of Q must be so corrected.

Assume that we want gas volume expressed at a pressure base P_b and temperature base T_b. According to Boyle's law, volume varies inversely as the absolute pressure and Charles' law, volume varies directly as the absolute temperature, therefore we correct the volume to the desired base and Equation (26) becomes:

$$Q = 218.44 E d^2 \frac{P_f}{P_b} \frac{T_b}{T_f} \sqrt{\frac{h\,T_f}{P_f\,G}}$$

or

$$Q = 218.44\ E\ d^2 \frac{T_b}{P_b} \sqrt{\frac{h\,P_f}{T_f\,G}} \quad (27)$$

Basic Factor F_b

If Equation (27) is to be put into practical use so that the value $218.44Ed^2$ can be used for each orifice diameter and pipe size, certain standards for pressure base P_b, temperature base T_b and specific gravity G must be made. The following assumption is nearly universal for most work in the gas industry.

1. Pressure base $P_b = 14.4$ lb/in^2.
2. Temperature base $T_b = 60°$ F or 520° R.
3. Flowing temperature $T_f = 60°$ F or 520° R.
4. Specific Gravity $G = 1$ (air).

By substituting these values in Equation (27), the formula becomes:

$$Q = 345.92\ E\ d^2 \sqrt{h\,P_f} \quad . \quad . \quad (28)$$

The value of the factor $345.92Ed^2$ is called the basic factor F_b to which correction factors to any set of conditions may be applied.

Besides standardizing on pressure base, temperature base and specific gravity factors, two assumptions must be made; they are

1. that the value $\sqrt{h\,P_f}$ is infinite, i.e., Reynolds No. $= \alpha$.
2. that $h/P_f = 0$, i.e., no expansion throughout the flow range.

If any of the real conditions vary from the above assumed value, the correction factor corresponding to that condition must be applied.

The basic factor $345.92Ed^2$ involves three parts, the constant 345.92, which is based on the fact that Q is expressed in cubic feet per hour, the orifice diameter d in inches, and the efficiency of the orifice "E," which will be discussed in detail below.

Efficiency Factor E

In the equation

$$Q = 218.44 d^2 \frac{T_b}{P_b} \sqrt{\frac{h\,P_f}{T_f\,G}} \quad (27)$$

E is an experimentally determined factor called efficiency of the orifice or discharge coefficient. It converts the ideal flow to actual flow, without using factor E, the Equation (27) would become:

$$Q = 218.44\ d^2 \frac{T_b}{P_b} \sqrt{\frac{h\,P_f}{T_f\,G}} \quad (27a)$$

which is only true under the following assumptions:

1. That the area of the jet at the plane of the downstream pressure tap is that of the orifice.
2. That the velocity of the gas before reaching the orifice is negligible.
3. That the gas does not change appreciably in density in passing through the orifice.
4. That the flow is streamlined and frictionless.
5. That the gas follows ideal gas laws.

If the above assumptions were true, then the E would not have to be used, the theoretical equation (27a) might be applied satisfactorily, but unfortunately, the assumed flow conditions are far from the actual fact, so correction is necessary.

In the analysis of the experimental data of E, there are five factors corresponding to the five assumptions above that influence the discharge coefficient E; they are:

A. Constriction of jet: Due to flow pattern of the fluid in passing through the plate region, the limiting or smallest area (vena contracta) is not exactly at the plate but somewhere downstream from the orifice. (See Part 1.) The result is extremely dependent on the condition of the upstream edge. The value of E, among other things, compensates for the exact amount of constrictions.

B. Velocity of approach: The velocity factor $[1/(1-\beta^4)]^{1/2}$, which has been discussed in Part 1, accounts for a great deal of the change of the value E.

C. Change in density of compressible fluid between upstream and downstream pressure: This effect will be discussed in detail as an expansion factor later.

D. Flow disturbances with its consequent loss of energy: This is due to (a) swirls and eddies, (b) velocity distribution effects (c) viscous flow. (Reynolds number factor.)

E. Deviation from Boyle's law: Will be discussed later as supercompressibility factor.

Before No. 2 Report, the method of analysis of the experimental data was such that all deviations from hydraulic formula were included in the value E, but in No. 2 Report, the expansion factor and the Reynolds number factor were isolated from E and must therefore, be applied separately when the basic factor F_b is used.

It was early assumed that the discharge coefficient E varied only as the ratio of orifice diameter to pipe diameter but recent research indicated that the ratio of differential head to static pressure h/P_f also influences the coefficient.

Thermodynamics also proved that the ratio of specific heat of the gas affects the expansion factor. Therefore, as a result, the coefficient E not only depends on β, but also depends on u, d, ρ and μ which four we group together in Reynolds number, and h, P_f, C_p/c_v which are involved in the expansion factor.

Now let

- C_v = change in efficiency for the plate due to location of vena contracta. This effect must be experimentally determined.
- C_a = velocity of approach factor
- Y = expansion factor, can be mathematically computed.
- C_t = turbulence factor excluding Reynolds number factor, must be experimentally determined.
- F_{pv} = supercompressibility factor, can be mathematically computed.
- F_r = Reynolds number factor, experimentally determined.

then

$$E \propto C_v, C_a, C_t, Y, F_{pv}, F_r$$

F_{pv} was separated as an individual correction factor.

No. 2 report separated the Y and F_r from E, hence greatly facilitated the evaluation and increased the range of application.

Assume Reynolds number to be infinity and h/P_f to be zero,

$$E = C_v \times C_a \times C_t$$

This E can then be experimentally determined for different pipe and orifice diameters, the values of E so obtained are multiplied by $345.92d^2$ to form the whole basic factor F_b, these values of F_b, tabulated against different values of D and d, are published in most orifice meter manuals.

Earlier Values of E

In Report No. 1, which was adopted prior to Report No. 2, the flow equation was:

$$Q = C \sqrt{h\,P_f}$$

in which

$$C = C_b \times F_{pb} \times F_{tb} \times F_{tf} \times F_g \times F_{pv} \times F_m \quad . \quad . \quad . \quad . \quad (24a)$$

and

$$C_b = 345.92\ E\ d^2 = \text{basic factor}$$

E_{pb}, F_{tb}, F_{tf}, F_g, F_{pv} and F_m being exactly the same as in Equation (24).

It will be noticed that the chief difference between Equation (24) and (24a) is that the factors Y and F_r were

neglected in (24a), and the factor E depended only on β.

There are some empirical equations for calculating E when experimental data are not available.

For flange taps, when $\beta > 0.41$

$$E = 0.606 + 1.25\ (\beta - 0.41)^2$$

For flange taps, when $\beta < 0.41$

$$E = 0.606$$

For pipe taps, ($2\frac{1}{2}$ D upstream and 8 D downstream)

$$E = 0.58925 + 0.2725\ \beta - 0.825\ \beta^2 + 1.75\beta^3$$

The value of E so calculated was used to substitute in the value $345.92Ed^2$.

If $\beta > 0.60$, these equations should not be used.

If the increased accuracy in Report No. 2 is not felt necessary, Equation (24a) may be used safely. For example:

An orifice equipped with flange taps using downstream static pressure connection, given

D = 4-in. line size = 4.026 in. actual inside diameter.

d = 2.000 in. orifice bore.

T_f = 60 F flowing temperature.

P_b = 14.4 lb per in.^{2} pressure base.

T_b = 60 F. temperature base.

G = 1.00.

Av. differential head h = 49 in. H_2O.

Av. downstream pressure P_f = 100 lb per square inch absolute.

Dry gas and no seal liquid used.

Find the orifice coefficient and average rate of flow.

Solution: Use Equation (24).

$$\sqrt{h P_f} = \sqrt{49 \times 100} = 70, \quad h/P_f = 49/100 = 0.49$$

From table, for 2″ orifice and 4″ line, $F_b = 861.42$

for $\sqrt{h P_f} = 70$, $F_r = 1.0006$

for $h/P_f = 0.49$, $Y_2 = 1.00295$

$F_{pb} = 1$, $F_{tb} = 1$, $F_{tf} = 1$, $F_g = 1$, $F_{pv} = 1$, $F_m = 1$

$\therefore C' = 861.42 \times 1.0006 \times 1.00295 = 864.0$ = orifice coefficient

$Q = C' \sqrt{49 \times 100} = 864.0 \times 70 =$ 60480 cu ft/hr = average flow rate.

Use Equation (24a)

From table

$C_b = 852.5$

$C = C_b = 852.52$

$Q = 852.5 \sqrt{49 \times 100} = 852.5 \times 70 = 59675$ cu ft/hr.

$$\text{deviation} = \frac{60408 - 59675}{60408} = 1.33\%$$

Reynolds Number Factor Fr

The AGA method for application of the Reynolds number factor is to publish the basic coefficient for a Reynolds number of infinite value and then modifying the coefficient in question by a factor corresponding to Reynolds number of the installation in question.

For natural gas work, the factor of viscosity does not vary seriously, it was assumed constant for all measurement. The velocity is a direct function of rate of flow and orifice diameter, density is a direct function of pressure, hence we can say that the Reynolds number depends on β, differential pressure h and static pressure P_f. Therefore, if d, D, and $\sqrt{hP_f}$ are known, F_r can be determined.

There are two methods for determining F_r:

A. In the range of operating conditions commonly met in natural gas measurement, a relationship was developed between Reynolds number correction factor F_r and the value of $\sqrt{hP_f}$.

Assuming viscosity and specific gravity of gas is constant,

$$F_r = 1 + \frac{r}{\sqrt{h P_f}}$$

where

r = a constant for a given orifice in a given pipe size with a specific pressure tap location. The value is published by AGA.

For other gases,

$$F_r = 1 + \frac{r}{\sqrt{h P_f}}\left(344.2\ \mu_1 \sqrt{\frac{T_f}{G}}\right)$$

where

μ_1 = viscosity in poises.

T_f = absolute flowing temp. °R.

G = sp gr (air = 1).

B. Additive Method of Correcting for Reynolds number.

This correction is independent of differential and static pressure within the range of operating conditions on which the AGA data are applicable.

Substituting $1 + \frac{r}{\sqrt{h P_f}}$ in the complete flow equation, and a coefficient omitting F_r is introduced.

Let

$$C_r = F_b \times Y \times F_{pb} \times F_{tb} \times F_{tf} \times F_g \times F_{pv} \times F_m \text{ (omitting } F_r)$$

then

$$Q = C_r \times F_r \sqrt{h P_f} = C_r \times \left(1 + \frac{r}{\sqrt{h P_f}}\right)\sqrt{hP_f}$$

$$\therefore Q = C_r \sqrt{hP_f} + C_r\, r$$

The additive $C_r\, r$ contains no variables, hence involves no averaging problem, therefore it is an exact correction regardless of fluctuation of differential and static pressure within the range covered by AGA data.

The Reynolds number factor thus obtained is multiplied into basic factor F_b to give proper value of the coefficient for that particular set of conditions.

It should be noted that if that basic factor is used, the Reynolds number correction factor must be used, for the basic factor F_b is given for a $\sqrt{hP_f}$ value of infinity, i.e., Reynolds = α, and Reynolds number is always less than infinity; thus in actual practice, the Reynolds number correction factor is always greater than 1.

Expansion Factor Y

It may be seen from Part 1 that the derivation of the hydraulic formula is based on the assumption that the gas does not change in density in passing through the orifice. At very low differential pressure and high static pressure this is approximately true, but actually, a gas varies its density in proportion to absolute pressure according to the gas law, and as the gas passes through the orifice an adiabatic expansion occurs, both the density and temperature of the gas will decrease with the drop in pressure, therefore the expansion factor is needed.

Experimental and mathematical study indicates that the ratio of the differential pressure to absolute static pressure h/P_f influences the orifice coefficient and bears direct relation to the expansion factor Y. Thermodynamics analysis also proves that the influence of change in density upon measurement at any ratio of differential to static pressure varies slightly with the ratio of specific heat of the compressible fluid, or c_p/c_v, and with the ratio of orifice to pipe diameter β.

For flow nozzles, well shaped orifices and venturi tubes, Y may be calculated from theoretical equation (40) derived in next section, in case of square-edged orifice, experimental determination of Y must be made. The following empirical equations give the numerical values of this factor:

For flange taps, and throat taps,

$$Y_1 = 1 - [0.41 + 0.35\ \beta^4]\frac{x}{s}$$

For pipe taps,

$$Y_1 = 1 - [0.333 + 1.145\ (\beta^2 + 0.7\ \beta^5 + 12\ \beta^{13})]\frac{x}{s}$$

For either flange and pipe taps,

$$Y_2 = Y_1 \sqrt{\frac{1}{1 - x}}$$

where

Y_1 = the expansion factor based on the absolute static pressure measured at the upstream connection.

Y_2 = the expansion factor based on the absolute static pressure measured at downstream connection.

x = ratio of differential pressure to upstream absolute static pressure in the same unit = $(P_1 - P_2)/P_1$.

s = ratio of sp. ht. = c_p/c_v

There are three systems in the static pressure connection, (a) upstream connection, (b) downstream connection, and (c) mean static pressure connection. It is obvious that the correction for expansion factor will vary for each of these systems.

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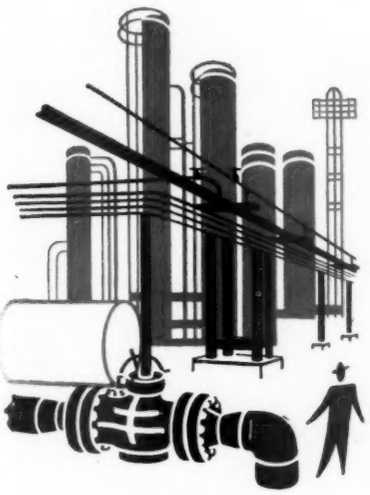

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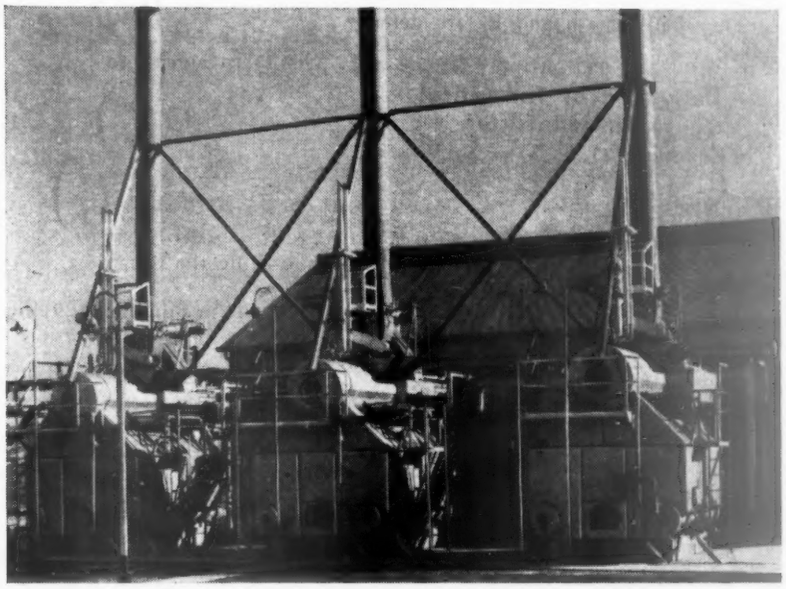

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meter, the static pressure connection is at the downstream tap for differential pressure, and with pipe connection meter, (2½ pipe diameter upstream and 8 pipe diameter downstream) static pressure connection is taken from upstream differential pressure connection. Recently a mean static pressure connection is also used, i.e., static pressure tap is taken at approximately halfway (in pressure value) between upstream and downstream differential taps.

When h is small and P_f is large, change in density will be small and therefore the expansion factor is relatively unimportant, but it becomes more important as h increases and P_f decreases.

As F_b in our formula of Report No. 2 is based on the assumption that $h/P_f = 0$, if F_b is used, Y must be used, no matter on what basis h and P_f are determined.

Derivation of Theoretical Expansion Factor

In Equation (2), let $X_1 = X_2$, $W = o$, $E = O$,
then

$$p_1v_1 + \frac{u_1^2}{2g} + \int_{v_1}^{v_2} pdv = p_2v_2 + \frac{u_2^2}{2g}$$

$$\therefore \frac{u_2^2 - u_1^2}{2g} = p_1v_1 + \int_{v_1}^{v_2} p\,dv - p_2v_2 \quad . \quad . \quad (29)$$

For ideal gas at adiabatic flow,

$$p_1v_1^s = p_2v_2^s = K \quad \therefore p = \frac{K}{v^s}$$

where
K = constant

$$s = \frac{c_p}{c_v}$$

Work of adiabatic expansion

$$W' = \int_{v_1}^{v_2} pdv = K\int_{v_1}^{v_2} \frac{dv}{v^s}$$

$$= K\,\frac{1}{1-s}[v_2^{1-s} - v_1^{1-s}] =$$

$$\frac{K}{s-1}\left(\frac{1}{v_1^{s-1}} - \frac{1}{v_2^{s-1}}\right)$$

Multiplying and dividing by

$$\frac{1}{v_2^{s-1}} \text{ or } \frac{1}{v_1^{s-1}}$$

$$W' = \frac{K}{s-1}\,\frac{1}{v_2^{s-1}}\left[\left(\frac{v_2}{v_1}\right)^{s-1} - 1\right]$$

or

$$W' = \frac{K}{s-1}\,\frac{1}{v_1^{s-1}}\left[1 - \left(\frac{v_1}{v_2}\right)^{s-1}\right]$$

Substituting the value of $K = p_2v_2^s = p_1v_1^s$ in above equations.

$$W' = \frac{1}{s-1}\,\frac{p_2v_2^s}{v_2^{s-1}}\left[\left(\frac{v_2}{v_1}\right)^{s-1} - 1\right]$$

$$= \frac{1}{s-1}p_2v_2\left[\left(\frac{v_2}{v_1}\right)^{s-1} - 1\right]. \quad (30)$$

or

$$W' = \frac{1}{s-1}\,\frac{p_1v_1^s}{v_1^{s-1}}\left[1 - \left(\frac{v_1}{v_2}\right)^{s-1}\right]$$

$$= \frac{1}{s-1}p_1v_1\left[1 - \left(\frac{v_1}{v_2}\right)^{s-1}\right]. \quad (31)$$

but

$$p_1v_1^s = p_2v_2^s$$

$$\therefore \frac{v_2}{v_1} = \left(\frac{p_1}{p_2}\right)^{\frac{1}{s}} \text{ or } \frac{p_1}{p_2} = \left(\frac{v_2}{v_1}\right)^s$$

Substituting into (30).

$$W' = \frac{1}{s-1}p_2v_2\left[\left(\frac{p_1}{p_2}\right)^{\frac{s-1}{s}} - 1\right]. \quad (32)$$

Similarly, substitute

$$\frac{v_1}{v_2} \text{ for } \left(\frac{p_2}{p_1}\right)^{\frac{1}{s}} \text{ in (31)}$$

$$W' = \frac{1}{s-1}p_1v_1\left[1 - \left(\frac{p_2}{p_1}\right)^{\frac{s-1}{s}}\right]. \quad (33)$$

Substitute the term

$$\int_{v_1}^{v_2} pdv \text{ in Equation (29) by (33)}$$

$$\frac{u_2^2 - u_1^2}{2g} = p_1v_1 + \frac{p_1v_1}{s-1} \times \left[1 - \left(\frac{p_2}{p_1}\right)^{\frac{s-1}{s}}\right] - p_2v_2. \quad (34)$$

but

$$p_2v_2^s = p_2v_2^{s-1}v_2 = p_1v_1^s = p_1v_1^{s-1}v_1$$

$$\therefore p_2v_2 = p_1v_1\frac{v_1^{s-1}}{v_2^{s-1}} = p_1v_1\left(\frac{p_2}{p_1}\right)^{\frac{s-1}{s}}$$

Substituting in (34)

$$\frac{u_2^2 - u_1^2}{2g} = p_1v_1 + \frac{p_1v_1}{s-1} \times \left[1 - \left(\frac{p_2}{p_1}\right)^{\frac{s-1}{s}}\right] - p_1v_1\left(\frac{p_2}{p_1}\right)^{\frac{s-1}{s}}$$

$$= p_1v_1\left(1 + \frac{1}{s-1}\right) - p_1v_1\left(\frac{p_2}{p_1}\right)^{\frac{s-1}{s}}\left(1 + \frac{1}{s-1}\right)$$

$$= \left(1 + \frac{1}{s-1}\right) p_1v_1 \left[1 - \left(\frac{p_2}{p_1}\right)^{\frac{s-1}{s}}\right]$$

$$\therefore \frac{u_2^2 - u_1^2}{2g} = \frac{s}{s-1}\,p_1v_1 \times \left[1 - \left(\frac{p_2}{p_1}\right)^{\frac{s-1}{s}}\right]. \quad . \quad (35)$$

From continuity, (conservation of mass)

weight rate $w_1 = w_2 = \frac{A_2u_2}{v_2} = \frac{A_1u_1}{v_1}$

$$\therefore u_1 = u_2\frac{A_2}{A_1}\frac{v_1}{v_2} = u_2\frac{A_2}{A_1}\left(\frac{p_2}{p_1}\right)^{\frac{1}{s}}$$

$$\therefore u_1^2 = u_2^2\left(\frac{A_2}{A_1}\right)^2 \times \left(\frac{p_2}{p_1}\right)^{\frac{2}{s}}$$

$$= u_2^2\beta^4\left(\frac{p_2}{p_1}\right)^{\frac{2}{s}}$$

Substituting in (35) and solve for u_2

$$u_2 = \sqrt{2g\frac{s}{s-1}p_1v_1\left[\frac{1 - \left(\frac{p_2}{p_1}\right)^{\frac{s-1}{s}}}{1 - \beta^4\left(\frac{p_2}{p_1}\right)^{\frac{2}{s}}}\right]}$$

. . . . . (36)

Since the weight rate of discharge

$$w = \frac{A_2u_2}{v_2} = \frac{A_2u_2}{v_1}\left(\frac{p_2}{p_1}\right)^{\frac{1}{s}}$$

Substitute u_2 by Equation (36)

$$w = CA_2\left(\frac{p_2}{p_1}\right)^{\frac{1}{s}} \times$$

$$\sqrt{2g\,\frac{s}{s-1}\,\frac{p_1}{v_1}\left[\frac{1 - \left(\frac{p_2}{p_1}\right)^{\frac{s-1}{s}}}{1 - \beta^4\left(\frac{p_2}{p_1}\right)^{\frac{2}{s}}}\right]}$$

$$= CA_2\sqrt{\frac{2g\,s\,p_1}{(s-1)\,v_1}} \times$$

$$\sqrt{\frac{\left(\frac{p_2}{p_1}\right)^{\frac{2}{s}} - \left(\frac{p_2}{p_1}\right)^{\frac{s+1}{s}}}{1 - \beta^4\left(\frac{p_2}{p_1}\right)^{\frac{2}{s}}}}$$

. . . . . (37)

in which C is a flow coefficient
Let

$$x = \frac{p_1 - p_2}{p_1} = 1 - \frac{p_2}{p_1}$$

$$\therefore \frac{p_2}{p_1} = (1 - x), \left(\frac{p_2}{p_1}\right)^{\frac{2}{s}} = (1 - x)^{\frac{2}{s}}$$

expand by binomial theorem and dropping terms of second and higher order in the series.

$$\left(\frac{p_2}{p_1}\right)^{\frac{2}{s}} \cong 1 - \frac{2}{s}\left(1 - \frac{p_2}{p_1}\right)$$

and

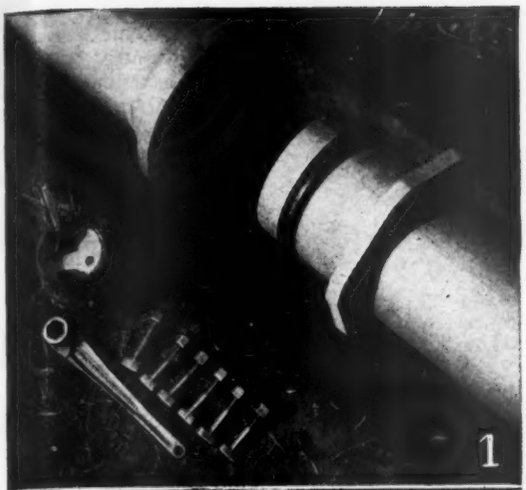
$$\left(\frac{p_2}{p_1}\right)^{\frac{s+1}{s}} \cong 1 - \left(\frac{s+1}{s}\right)\left(1 - \frac{p_2}{p_1}\right)$$

Substituting in (37)

$$w = CA_2\sqrt{\frac{2g\,(p_1 - p_2)}{v_1\left[1 - \beta^4\left(\frac{p_2}{p_1}\right)^{\frac{2}{s}}\right]}}$$

. . . . . (38)

The term $1 - \beta^4\left(\frac{p_2}{p_1}\right)^{\frac{2}{s}}$ is the velocity



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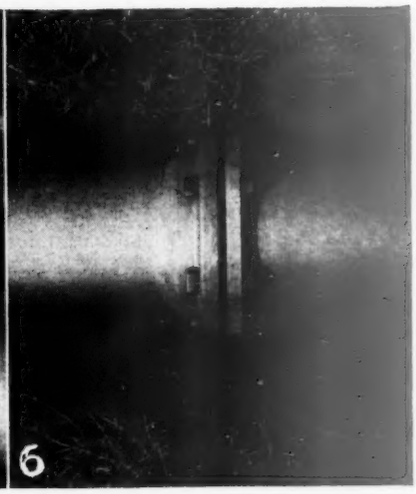

of approach factor and can be included in C. It was shown that C is not influenced to any appreciable extent by a reasonable variation of pressure ratio p_2/p_1, therefore the velocity factor can be taken as $(1-\beta^4)$ and Equation (38) reduces to:

$$w = CA_2 \frac{1}{\sqrt{1-\beta^4}} \sqrt{\frac{2g\,(p_1-p_2)}{v_1}} \quad \ldots\ldots\ldots\ldots (39)$$

which is the simple hydraulic equation for incompressible fluids.

Let

$$Y = \text{expansion factor} = \frac{\text{wt. rate of compressible flow}}{\text{wt. rate of incompressible flow}}$$

$$\therefore Y = \frac{\text{eq. (37)}}{\text{eq. (39)}} =$$

$$\sqrt{\frac{(1-\beta^4)\left[\left(\frac{p_2}{p_1}\right)^{\frac{2}{s}} - \left(\frac{p_2}{p_1}\right)^{\frac{s+1}{s}}\right]}{\left(\frac{s-1}{s}\right)\left(1-\frac{p_2}{p_1}\right)\left[1-\beta^4\left(\frac{p_2}{p_1}\right)^{\frac{2}{s}}\right]}} \quad \ldots\ldots\ldots\ldots (40)$$

This rational expansion factor is applicable for flow nozzles, well shaped orifices, and venturis, where head loss due to eddy current and turbulence is small, but for square-edged orifices, experimental determination must be made. Some empirical equations, however, were given in "Fluid Meters, Their Theory and Application," Part 1, by ASME. These equations have been shown in the preceding section, they can be used to compute the numerical values of Y in Equation (24). But in using these equations, Y should be used only in the limits $p_2/p_1 \geq 0.8$ and ≤ 1.0, for which they are accurate to within 0.5 per cent. If the ratio exceeds the range, Y must be determined experimentally.

Pressure Base Factor F_{pb}

The value of basic factor F_b of Report No. 2 is based on absolute pressure of 14.4 lb/in² and if the base pressure differs from this, a base pressure correction must be multiplied into the coefficient.

Pressure base factor is to change from a pressure base of 14.4 psi absolute to some other desired pressure base. (Contract pressure base.)

$$F_{pb} = \frac{P_b}{P_{b_1}}$$

where

P_b = 14.4 psi abs. (note that atmospheric pressure is higher than base pressure).

P_{b_1} = abs. pressure of the desired base pressure.

Temperature Base Factor F_{tb}

Temperature factor is to change from a temperature base of 60 F to contract (desired) temperature base.

$$F_{tb} = \frac{T_b}{T_{b_1}}$$

where

T_b = temperature base = 520 R.

T_{b_1} = desired base temperature, °R.

Most tables use a base of 60 F or 520° R, therefore F_{tb} usually = 1.

Flowing Temperature Factor F_{tf}

Flowing temperature factor is the factor to change from assumed flowing temperature of 60 F to actual flowing temperature.

In the computation of the basic factor F_b, and other factors, the temperature of the flowing gas is assumed to be 60 F. If, in practice the flowing temperature departs from this, a temperature correction should be made.

In Equation (27), note the value of T_f is under the radical in the denominator, thus if the flowing temperature increases for any flow condition, the actual volume of gas reduced to base temperature must be reduced by the ratio of $\sqrt{520}$ to $\sqrt{T_{f_1}}$

$$F_{tf} = \sqrt{\frac{T_f}{T_{f_1}}}$$

where

$T_f = 520$ °R.

T_{f_1} = absolute temperature of °F (°R) of the flowing gas.

Specific Gravity Factor F_g

Specific gravity factor is to adjust for specific gravity of the gas other than 1. In Equation (27), basic factor F_b is based on a gas of specific gravity = 1, therefore for any given gases of the specific gravity other than 1, this factor must be applied to correct it.

$$F_g = \sqrt{\frac{G}{G_1}}$$

where

$G = 1$ (air).

G_1 = specific gravity of flowing gas.

Supercompressibility Factor F_{pv}

In all the derivation of formulas we have assumed that the gases are ideal gases, i.e., the gases completely obey the Boyle's law. For actual gases, however, this law does not hold perfectly true. As the gas is compressed, its volume contracts and its density increases by an amount greater than that given by computation based on Boyle's law, similarly, when a given volume of gas at a given pressure is expanded to lower pressure, it will occupy a greater volume than computation by Boyle's law could indicate. This is the supercompressibility of gas, or sometimes termed superexpansibility. F_{pv} is the factor to correct for this deviation from ideal gas laws.

Supercompressibilities of air, CO_2, etc., have been quite thoroughly determined by test. But petroleum gases are of great variation in chemical composition, hence no data have been determined with great accuracy. However, correction for supercompressibility is important if the gas is measured at high pressure.

Let

P_c = absolute value of apparent static pressure, lb/in.², i.e., the pressure at which the high pressure gas would have had to exist if Boyle's law held exactly.

P_f = actual absolute static pressure, lb/in.², i.e., absolute flowing pressure determined from chart or pressure gage.

Z = supercompressibility.

then

$P_c = Z P_f$

Equation (28) should be

$$Q = 345.92\ E\ d^2 \sqrt{h\,P_c}$$

$$= 345.92\ E\ d^2 \sqrt{Z} \sqrt{h\,P_f}$$

$$\therefore F_{pv} = \sqrt{Z} = \sqrt{\frac{P_c}{P_f}}$$

To obtain an exact supercompressibility factor it is necessary to have a curve of p_c vs. p_f, or P_c vs. P_f for the gas in question (by use of Bureau of Standards Deviation Apparatus or Pacific Gas and Electric Deviation Apparatus) p_c and p_f being the apparent gage pressure and actual gage pressure respectively.

In absence of more exact data, the value given by the following empirical equations may be used. It is determined from many gases by the natural gas industry on the Pacific Coast and the value computed from the equation may be regarded typical and representative, but it should not be used as a substitute for data actually based on the gas in question when it is possible to make such determinations.

For G = 0.75 to 1.00,

$$F_{pv} = \sqrt{\frac{1+p_f \times 9.16 \times 10^5 \times 10^{1.188\,G}}{T_f^{3.825}}}$$

For G = 0.55 to 0.75,

$$F_{pv} = \sqrt{\frac{1+p_f \times 3.444 \times 10^5 \times 10^{1.785\,G}}{T_f^{3.825}}}$$

in which

p_f = pressure lb/in.² gage.

G = specific gravity of gas (air = 1).

T_f = flowing temperature °R.

Correction for Moisture F_m

This correction is to reduce the volume of flowing gas to a specific state of relative humidity.

Correction involves two parts:

1. Correction for partial pressure of

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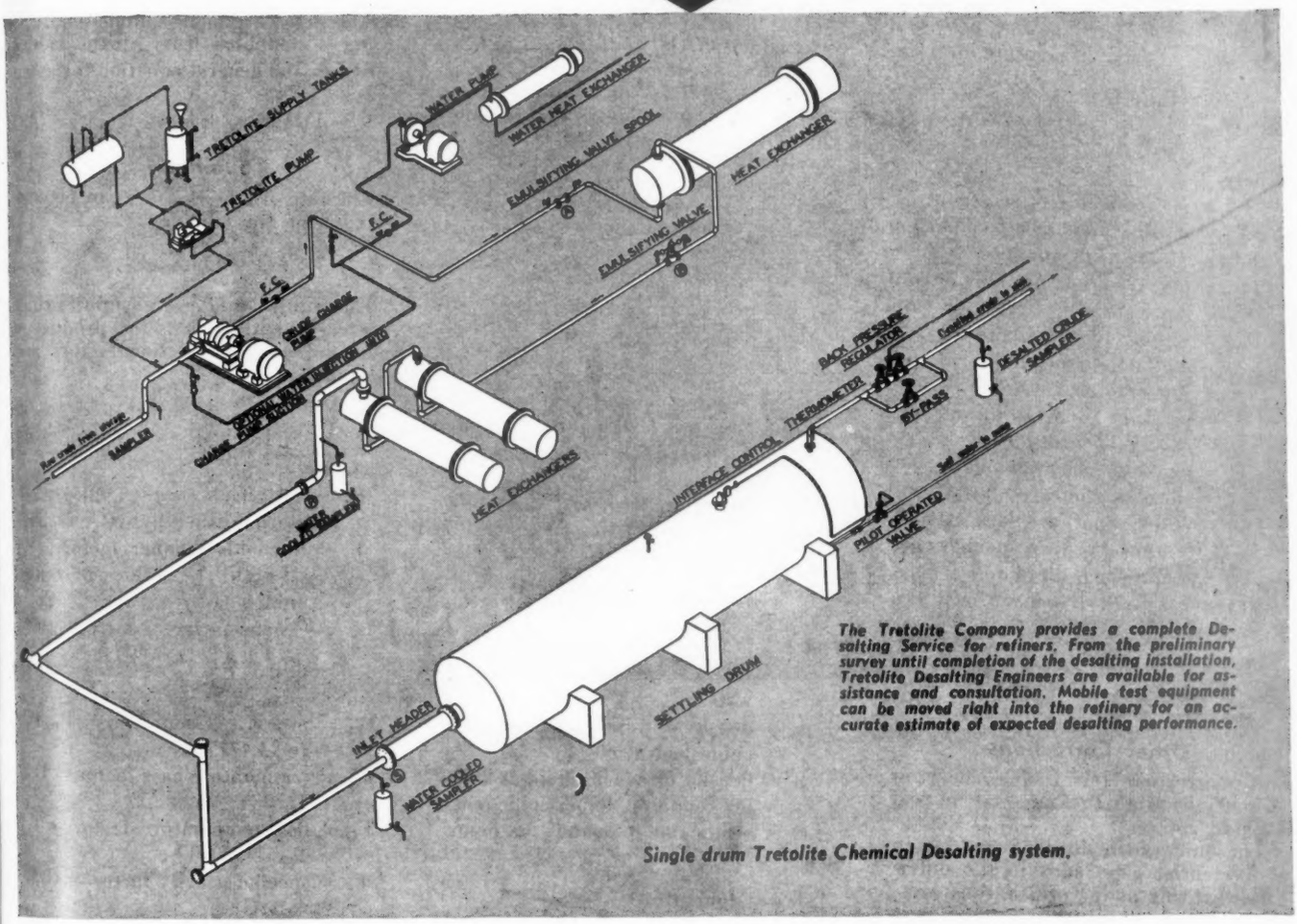

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moisture content in gas that is added to the actual flowing pressure of gas.

2. Correction for reducing the volume of gas to a contract state of relative humidity.

The general formula for this correction is:

$$F_m = \left(\frac{P_f - R_f P_{wf}}{P_f}\right) \Big/ \left(\frac{P_b - R_b P_{wb}}{P_b}\right)$$

in which

$\left(\frac{P_f - R_f P_{wf}}{P_f}\right)$ = per cent partial pressure of dry gas at flowing temperature.

$\left(\frac{P_b - R_b P_{wb}}{P_b}\right)$ = per cent partial pressure of dry gas at base temperature.

$$\therefore F_m = \frac{P_f - R_f P_{wf}}{P_f} \times \frac{P_b}{P_b - R_b P_{wb}}$$

where

F_m = moisture correction factor.

P_f = flowing pressure in pounds per square inch absolute.

R_f = per cent relative humidity of flowing gas ÷ 100.

P_{wf} = water vapor pressure at flowing temperature in pounds per square inch absolute.

P_b = pressure base, pounds per square inch absolute.

R_b = per cent relative humidity specified by contract ÷ 100.

P_{wb} = water vapor pressure at base temperature in pounds per square inch absolute.

If the gas is dry, such as city gas, $R_f = 0$, then

$$F_m = \frac{P_b}{P_b - R_b P_{wb}} \text{ (for dry gas only)}$$

Other Corrections

A. Correction for Displacement of Mercury by High Pressure Gas or Seal Liquid:

The fluid which displaces the Hg in a differential gage adds to the differential existing at the orifice, thus causing a higher reading in a float type meter. During low pressure gas measurement, the effect is so small that it may be safely neglected, but for high pressure gas, whose density is great enough to cause an error of ½ — 2 per cent, the correction factor then must be applied. The same case is true when a liquid seal is used in measurement of corrosive gases such as Cl_2 and HCl, etc.

$$F_s' = \sqrt{\frac{\rho_m - \rho_s}{\rho_m}} = \sqrt{1 - 0.00118\,\rho_s}$$

where

F_s' = correction factor for displacement of Hg in differential gage.

ρ_m = density of Hg, lb per cu ft.

ρ_s = density of gas or liquid on surface of Hg, lb per cu ft.

This correction factor is then multiplied in to flow Equation (23).

B. Correction for Thermal Expansion of Primary Element:

If the temperature of flowing gas is pretty high, e.g., steam, the correction for expansion of orifice bore is necessary.

The correction factor F_e = $\frac{\text{(orifice diameter)}^2 \text{ at flowing temp.}}{\text{(orifice diameter)}^2 \text{ at 60 F}}$

$$= \frac{d'^2}{d^2}$$

Measurement of Vapor and Steam

The behavior of vapors that liquefy near atmospheric conditions deviates from ideal gas laws not only at flowing conditions but also at base conditions and at conditions under which the specific gravity is determined. Therefore, in steam or vapor measurement, the most commonly used unit is pound per hour. The flow rate in weight units eliminates the need for base correction and specific gravity correction.

Refer to basic Equation (25),

$$Q = 19.64\ E\ d^2 \sqrt{2g\,\Delta H}$$

where

Q = flow rate in cubic feet per hour.

ΔH = pressure loss across the plate expressed in feet of head of flowing fluid.

If we convert the head of flowing fluid into head in inches of water,

$$\Delta H = \frac{h}{12} \times \frac{\rho_w}{\rho}$$

where

h = differential head in inches of water.

ρ_w = density of water = 62.37 lb per cubic foot at 60 F.

ρ = density of flowing fluid at flowing condition, lb per cubic foot.

Let w = flow rate in pounds per hour, then $w = Q \times \rho$.

$$\therefore w = 19.64\ E\ d^2 \sqrt{\frac{2 \times 32.17 \times 62.37 \times h}{12 \times \rho}} \times \rho$$

$$= 359.15\ E\ d^2 \sqrt{h\,\rho}$$

When using AGA basic factor F_b instead of $359.15Ed^2$

$$w = \frac{359.15}{345.92} \times 345.92Ed^2 \sqrt{h\,\rho} =$$

$$1.038\ F_b \sqrt{h\,\rho} \quad . \quad . \quad . \quad . \quad (41)$$

This is the basic equation for measurement of vapors and steam, correction factors for any set of conditions may be applied to this basic equation.

Values of ρ for some common industrial gases such as NH_3 and CO_2 are available from handbooks or the literature. For other vapors it may be computed from the equations of Dieterici, Van der Waal, or Berthelot.

For steam measurement, water seal is provided over the Mercury, the correction factor for this seal liquid is:

$$F_s' = \sqrt{1 - 0.00118\,\rho_s}$$

$$= \sqrt{1 - 0.00118 \times 62.37}$$

$$= \sqrt{0.9263} = 0.962$$

$$w = 1.038 \times 0.962\ F_b \sqrt{h\,\rho} = F_b \sqrt{h\rho}$$

where ρ must be computed from Steam Tables for each measurement condition.

The error caused by omitting the Reynolds number factor, F_r, may be neglected safely. The expansion factor Y should be applied as usual, all corrections for density and supercompressibility, etc., are made automatically by using ρ computed from Steam Tables, therefore the general equation for steam is:

$$w = F_b\ Y\ F_e \sqrt{h\,\rho} \quad . \quad . \quad . \quad . \quad (42)$$

Summary

The rate of flow of gases can be computed from the equation:

$$Q = C' \sqrt{h\,P_f}$$

The multiplier C′ is an over-all orifice flow coefficient which is the product of some individual correction factors and constants.

$$C' = F_b \times F_r \times Y \times F_{pb} \times F_{tb} \times F_{tf} \times F_g \times F_{pv} \times F_m$$

in which

F_b = basic factor = $345.92Ed^2$, values published by AGA.

F_r = Reynolds number factor = $1 + r/(hP_f)^{1/2}$, values of r also published by AGA.

Y = expansion factor = $1 - (0.41 + 0.35\,\beta^4)\frac{x}{s}$, (flange tap).

F_{pb} = pressure base factor = $P_b/P_{b_1} = 14.4/P_{b_1}$.

F_{tb} = temperature base factor = $T_{b_1}/T_b = T_{b_1}/520$

F_{tf} = flow temperature factor = $T_f/T_{f_1} = 520/T_{f_1}$.

F_g = specific gravity factor = $G/G_1 = 1/G_1$.

F_{pv} = supercompressibility factor = P_c/P_f.

F_m = moisture correction factor = $\frac{P_f - R_f + P_{wf}}{P_f} \times \frac{P_b}{P_b - R_b P_{wb}}$

In any given measurement condition, if any of the six factors assumed in computing basic factor F_b, i.e.,

1. Pressure base $P_b = 14.4$ psia.
2. Temperature base $T_b = 520$ °R.
3. Flow temperature $T_f = 520$ °R.
4. Specific gravity $G = 1$ (relative to air at 60 F).
5. Reynolds number = α i.e., $\sqrt{hP_f} = \alpha$.

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6. Expansion factor = 0, i.e., $h/P_f = 0$.

vary from the assumed values, the basic factor must be modified by multiplying by the corresponding correction factor.

In case the flow temperature is high or the pressure is high or seal liquid is employed, the following correction factors should be multiplied onto C′.

$$F_s' = \sqrt{1 - 0.00118\,\rho_s}$$

(Correction factor for weight of fluid above Hg.)

$$F_e = d'^2/d^2$$

(Correction factor for thermal expansion of orifice plate.)

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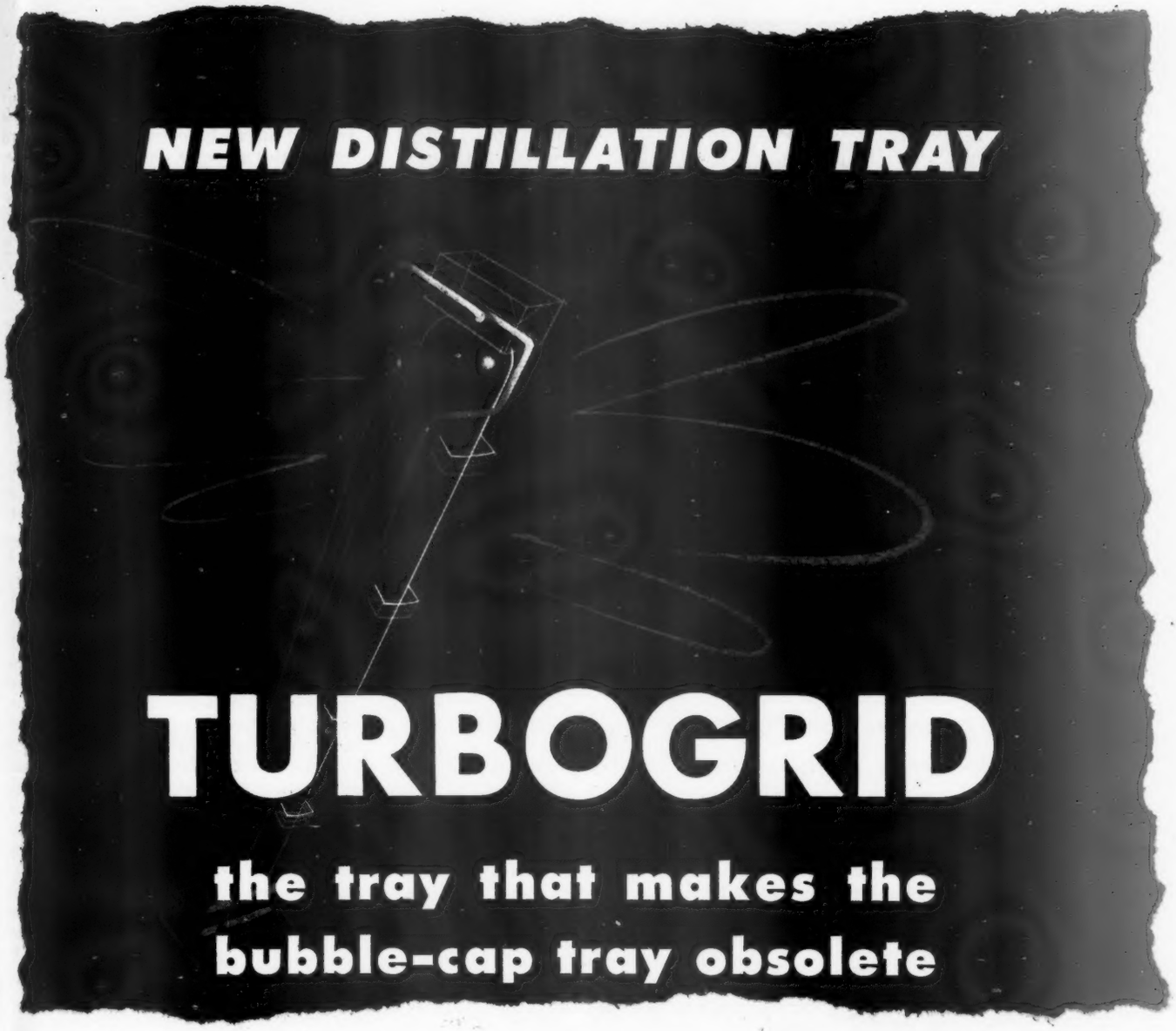
Nomenclature

A_o = orifice area in sq ft.
A_1 = cross sectional area of pipe, sq ft.
C = orifice flow coefficient for gas (AGA Report No. 1).
C′ = orifice flow coefficient for gas (Report No. 2).
C″ = orifice flow coefficient for liquid.
C_b = basic factor for gas formula (Report No. 1).
C_r = orifice flow coefficient for gas, excluding F_r, (Report No. 2).
C_a = velocity of approach factor.
C_t = turbulence factor.
C_v = vena contracta factor.
c_p = specific heat of gas at constant pressure.
c_v = specific heat of gas at constant volume.
d = rated orifice diameter in inches.
d′ = orifice diameter in inches, at flowing temperature.
d″ = orifice diameter in feet at flowing temperature.
D = internal diameter of pipe in inches.
E = coefficient of charge or efficiency factor of orifice.
E_1 = upstream internal energy of fluid.
E_2 = downstream internal energy of fluid.
F = friction loss, ft × lb/lb.
F_b = basic factor for gas flow formula (Report No. 2).
F_b' = basic factor for liquid flow formula.
F_e = orifice plate expansion factor.
F_g = specific gravity factor.
F_m = moisture factor.
F_{pb} = pressure base factor.
F_{pv} = supercompressibility factor.
F_r = Reynolds number factor.
F_s = seal liquid factor.
F_s' = factor for weight of fluid above Hg.
F_t = temperature factor.
F_{tb} = temperature base factor.
F_{tf} = flow temperature factor.
F_z = ratio of specific gravity of liquid at flowing temperature to its specific gravity at 60 F.
g = acceleration due to gravity, ft/sec².
G = specific gravity of gas.
G_b = specific gravity of flowing liquid at 60 F.
G_f = specific gravity of flowing liquid at flowing temperature.
G_m = specific gravity of mercury.
G_s = specific gravity of liquid displacing manometer Hg.
h = gage or chart reading of differential pressure in inches of water.
h′ = differential pressure in inches of water, with air above Hg.
h″ = differential pressure between seal liquid and flowing liquid.
Δ h = differential pressure in inches of flowing fluid.
Δ H = differential pressure in feet of flowing fluid.
K = a constant.
N = unit conversion factor.
p = static pressure of flowing fluid, lb/ft² absolute.
p_1 = upstream static pressure, lb/ft² absolute.
p_2 = downstream static pressure, lb/ft² absolute.
P_b = pressure base, 14.4 psi absolute.
P_{b_1} = desired pressure base, psi absolute.
p_f = static pressure of gas, psi gage.
P_f = static pressure of gas, psi absolute.
P_c = apparent static pressure of gas, psi absolute.
P_{wb} = water vapor pressure at base temperature psi absolute.
P_{wf} = water vapor pressure at flowing temperature psi absolute.
q = heat added to orifice system from external sources, ft × lb/lb.
Q = rate of flow.
r = a constant correlate with F_r.
R_b = per cent relative humidity specified by contract ÷ 100.
R_f = per cent relative humidity of gas ÷ 100.
Re = Reynolds number.
s = ratio of specific heat of gas, c_p/c_v.
T_b = temperature base, 520 °R.
T_{b_1} = desired temperature base, °R.
T_f = assumed flowing temperature, 520 R.
T_{f_1} = absolute temperature of flowing gas, °R.
u = velocity of flowing fluid in ft/second.
u_o = velocity of flowing fluid at orifice ft/sec.
u′ = velocity of fluid, ft/hr.
u_1 = upstream velocity of fluid, ft/sec.
u_2 = downstream velocity of fluid, ft/sec.
v = specific volume of fluid, cu ft/lb.
v_1 = specific volume of upstream fluid, cu ft/lb.
v_2 = specific volume of downstream fluid, cu ft/lb.
V = rate of flow in gph.
V′ = rate of flow in gph at flowing temperature.
V″ = indicated gph.
w = weight rate of flow, pounds per hour.
W = work done by outside device, ft × lb/lb.
W′ = work done by fluid in adiabatic expansion, ft × lb/lb.
x = ratio of differential pressure to upstream pressure $(p_1 - p_2)/p_1$.
X = potential head of flowing fluid, feet.
Y = expansion factor.
Y_1 = expansion factor based on upstream absolute static pressure.
Y_2 = expansion factor based on downstream absolute static pressure.
Z = supercompressibility.
α = coefficient of expansion of orifice plate material.
β = ratio of orifice diameter to pipe diameter.
ρ = density of flowing fluid at flowing condition, lb/ft³.
ρ_m = density of mercury, lb/ft³.
ρ_s = density of fluid above Hg surface, lb/ft³.
ρ_a = density of air at 32 F and 1 atm, lb/ft³.
ρ_w = density of water at 60 F. lb/ft³.
μ = absolute viscosity of flowing fluid, English unit, lb/ft sec.
μ' = kinetic viscosity in SUS at flowing temperature.
μ'' = absolute viscosity of fluid in centipoise, at flowing temperature.
μ_1 = absolute viscosity in poise.

* * *

NEW DISTILLATION TRAY



TURBOGRID

the tray that makes the bubble-cap tray obsolete

HIGHER THROUGHPUT is assured when using Turbogrid trays, because they have much higher capacity per square foot of column cross-section at equal separating efficiency and much lower pressure-drop.

The simple, rugged design of this tray assures both **low fabrication and installation costs,** and low costs of maintenance. Also *stainless steel* can be used at *no extra* cost since the tray can be stamped out of sheet metal.

Replacing your old trays with Turbogrid trays may even double the capacity of existing columns without loss in separating efficiency . . . and at a cost which you will find attractive.

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Your inquiries are invited. Turbogrid trays are available through selected contractors under license from Shell Development Company.

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SHELL

Virgo molten cleaner at Hooker Electrochemical Company.

Cleaner Salvages Equipment

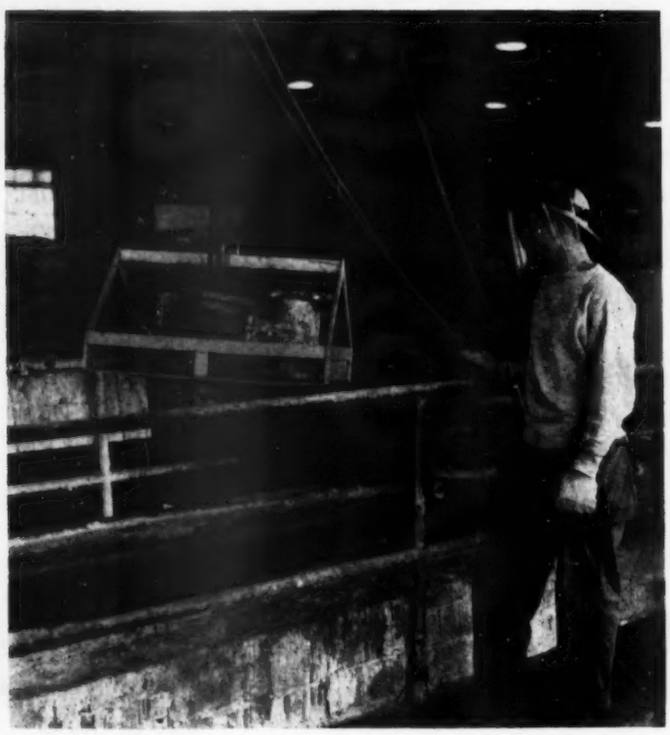
Product removes paint, dirt, rust, and chemical impurities from metal surfaces in 15 minutes

A NEW method for salvaging refinery and gasoline plant, as well as other metal equipment has been developed by Hooker Electrochemical Company, originally worked out for use in the company's own plants. This new system employs what are trade-named Virgo molten cleaner, and Virgo descaling salt. By means of the latter paint, dirt, rust, and chemical impurities are removed to give a clean metal surface or piece in 10-15 min, according to statements made by company technologists. The first product degraphitizes and de-enamels equipment.

The process includes the cleaner salt and a salt bath or vat; a water quench vat and an acid treating bath, followed by a water rinse to complete the cycle. These vats may be arranged in line and continuous conveyor arrangements handle the equipment to be cleaned, from beginning to end of the cycle. Temperature of the salt bath ranges from 800 F to 930 F, the particular job to be done determining the temperature to be employed. The "salt" is a mixture of salts, which accomplishes the required purpose.

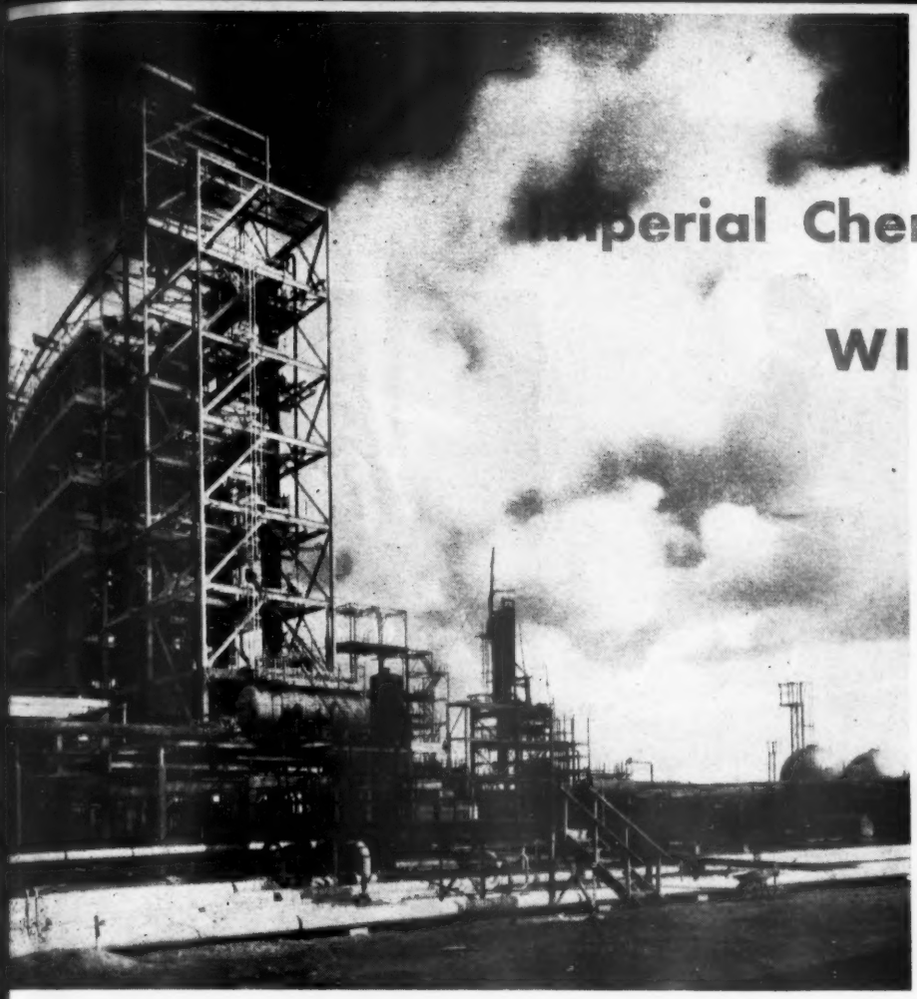
The process is carried out by immersing the pieces to be cleaned in the molten salt bath at the required temperature for about 15 min. Oxidizing agents in the salt change ferrous oxide, FeO, and Fe_3O_4 to Fe_2O_3, ferric oxide, in which form the oxide is attacked easily by the subsequent acid bath solution (hydrochloric acid in water). One atom of additional oxygen is added in so converting one molecule each of the above oxides. The oxygen is obtained from the salt and is replaced by air contact such as by blowing or by normal air contact with the molten bath surface. Unequal expansion-contraction of oxides and metallic metal causes cracks to appear in the coatings, allowing easy access of acid to dissolve the impurities. Chromium oxides are dissolved in the descaling salt; removal of the soluble parts of the scale leave insoluble material as loose dust or smut easily removable by brushing or spraying.

Mild steel is used for the tanks except the acid tanks where standard acidware is employed. Sulfuric acid may be used instead of muriatic acid. * * *



Pipe fittings covered with paint, rust and chemical corrosion hang in carrier over cleaning bath.

The same fittings coming out of Virgo molten cleaner are ready for further service.



Imperial Chemical Industries

WILTON WORKS

Britain builds up new chemical industry and improves refining techniques with increased use of petroleum products

V. S. SWAMINATHAN

Part of the olefin plant, looking east.

As late as the end of the second world war Great Britain obtained the bulk of her organic chemicals from the two traditional sources—coal, through coal tar and calcium carbide, and animal and vegetable products. Since then petroleum has become another major raw material source for the manufacture of an exceptionally wide range of valuable organic chemicals. Crude oil has advantages over coal as a starting material for the building up of new chemicals in being liquid, and in the fact that hydrogen is already combined with carbon. Also it is more easily and cheaply transported than vegetable products, and gives a higher yield of synthetic chemicals on a weight-for-weight basis. Again, oil has enjoyed a stable price over a long period, and its price increase has been less marked than that of coal. Above all, recent remarkable advances in refining techniques, such as catalytic cracking, hydroforming, platforming, etc., with the object of obtaining increased yields of gasoline of improved quality, have resulted in a much greater availability of reactive gases forming admirable "bricks" for manufacturing chemicals. Last, the removal by the British Government at the end of the last war of the hydrocarbons oil duty from oils required for chemical synthesis has made it possible to begin large-scale operations in United Kingdom based on imported crude petroleum that can be cracked to yield reactive olefinic gases.

The rapid development and production of the Middle East oil fields, which rose from 16,000,000 tons in 1938 to 88,000,000 tons in 1950, posed the problem of arranging for the refining of crude petroleum. The post-war trend in the eastern hemisphere has generally been to build new refineries near the points of consumption rather than adjacent to the oil fields. One of the major factors in determining this policy was the desire of Western European countries to economize in foreign exchange by importing crude oil instead of finished products. A further consideration was the growing appreciation of the value of establishing a petroleum-based chemical industry to make use of certain of the refinery products. The effect of the development of a home refining policy in Western Europe has been to increase such capacity from 20,000,000 tons in 1939 to 50,000,000 tons in 1951, with an objective of over 60,000,000 tons in 1953. The United Kingdom has shared fully in this expansion and British refining capacity has risen from 3,500,000 tons in 1939 to 20,000,000 tons in 1951, with a target of 26,000,000 tons in 1953. Apart from this marked increase in throughput capacity there has been a noteworthy development in the character of plant installed, mainly through the advance of the catalytic cracking technique. By the end of 1952 the catalytic cracking capacity of British refineries is scheduled to reach nearly 10,000 long tons a day.

EXCLUSIVE

Two main steps are involved in manufacturing petrochemicals, between the raw material and end product, namely, the breakdown of any given feedstock into their component hydrocarbons, or, their closely related groups; and synthesis, or building up, of the desired products from the individual components from refinery operations. The main raw materials used on the purely synthetic side of the industry are the olefinic constituents of cracked oil, from which are derived directly, or indirectly, the majority of the tonnage end products — synthetic detergents, solvents, plastics, fibres, and rubbers. Major British petrochemical projects fall under four headings: Those based wholly on oil (the Shell Stanlow plant and the Cabot and Philblack carbon black plants); oil and chemical (British Petroleum Chemicals, promoted jointly by the Anglo-Iranian and the Distillers companies); oil and chemical consumers (Petrochemicals, Ltd., in conjunction with four main consumers), and purely chemical enterprises (Imperial Chemical Industries [I.C.I.] Ltd., and Monsanto Chemicals Ltd.)

Imperial Chemical Industries (I.C.I.) Ltd., is the largest undertaking in the British Commonwealth, and the leading manufacturing enterprise in the United Kingdom. It has an issued capital of approximately £85 million, and operates more than a hundred factories in Britain, which employed at the end of 1950 (including those in H. M. Government Agency establishments) 104,638 per-

The only evidence of Lummus at this stage of the project is a team of 'dozers doing initial clearing. But soon it will be a completely-integrated petroleum refinery . . . or a modern chemical plant . . . or petroleum chemical units employing the newest and best processing concepts.

Meanwhile, the earth-movers are prophetic. They signal the application of Lummus' complete one-contract, one-responsibility engineering service from initial studies through acceptance run. And the trademark they wear means that *every* Lummus man who has a hand in the project has a strong and steady desire to make *this* the best job ever turned out by the company.

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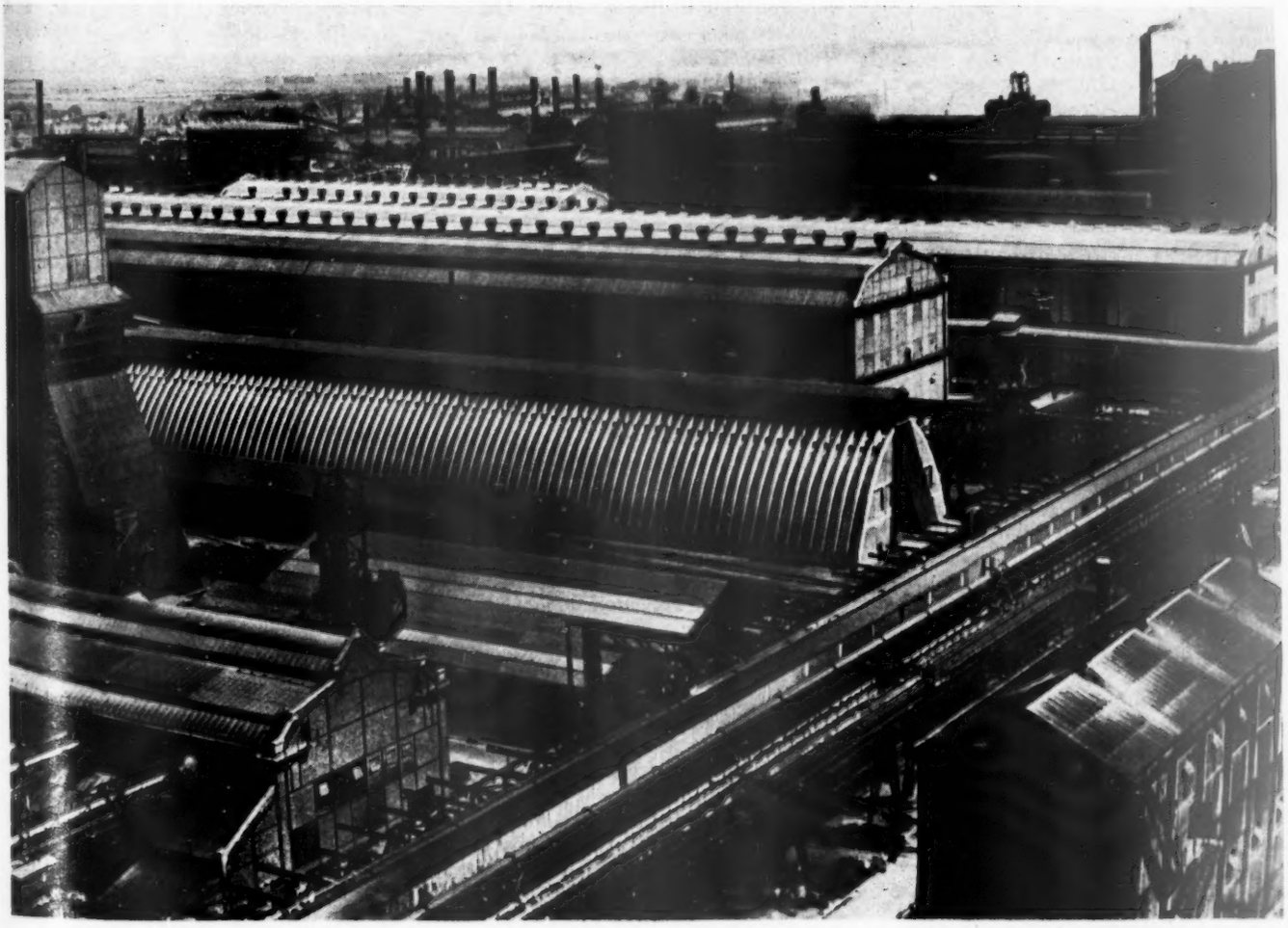
DESIGNING ENGINEERS AND CONSTRUCTORS FOR THE PETROLEUM AND CHEMICAL INDUSTRIES

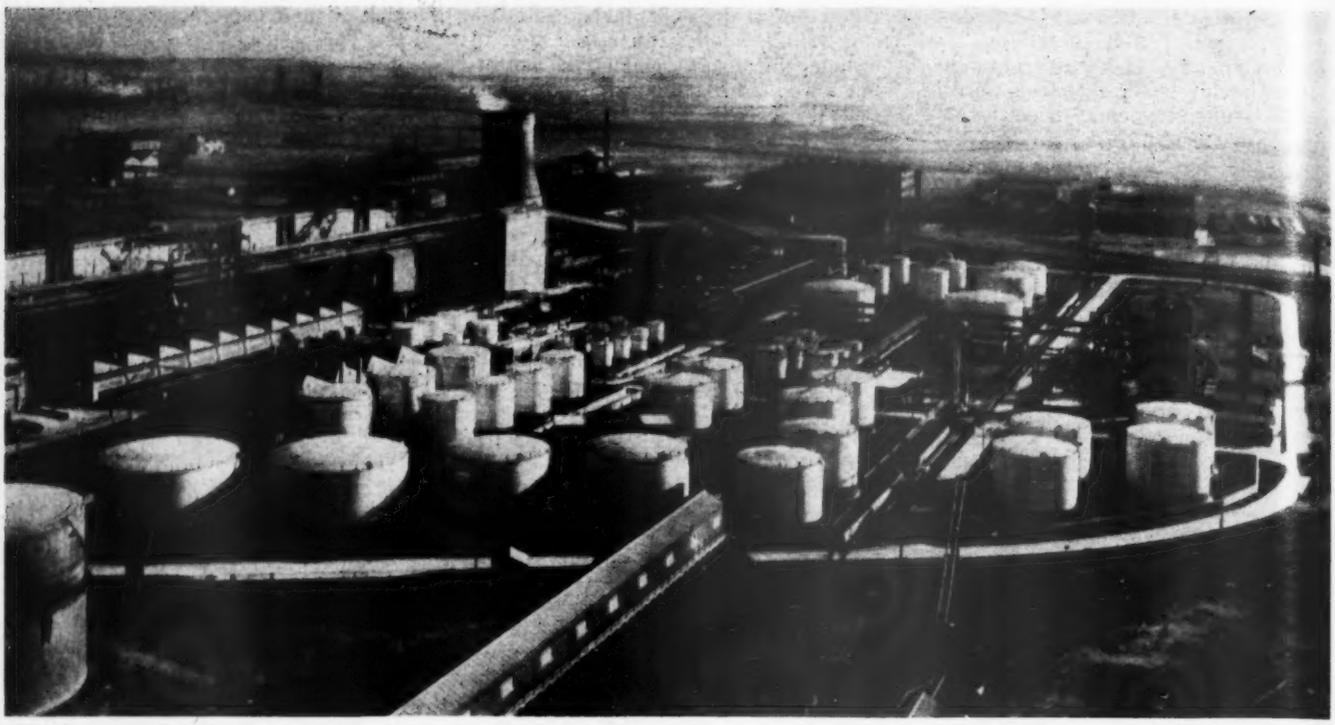
sons, comprising 27,510 staff (including foremen), and 77,128 operatives. The company produces 12,000 different products embracing heavy chemicals, fertilizers, dyestuffs, medicinal drugs, explosives, plastics, paints, non-ferrous metals, and slide fasteners. Its manufacturing capacity is based on its dozen production units, designated divisions, producing primarily alkalis, fuels and fertilizers, dyestuffs, pharmaceuticals, general chemicals, leather cloth, lime, metals, explosives, paints, plastics, and salt. The total value of I.C.I.'s consolidated sales to customers in 1950 was £220.8 million, and exports that year reached the record figure of £48.4 million. This chemical giant has manufacturing interests in nine overseas countries, smaller production units in five others, merchanting companies in all these territories and 18 more. In addition, there are selling agents for its products in almost every country, save Russia and some of her satellite states. In 1950 the company's expenditure on research and development amounted to £5.5 million. I.C.I.'s post-war expansion plans call for an estimated capital outlay of £80 million, of which £22 million are allocated to the first stage of the mammoth Wilton project.

The Wilton project is a grand adventure in divisional co-operation. It is a federation of division plants, each division being wholly responsible for its own technical and commercial matters but all united together with the Wilton central organization in the development and administration of Wilton as one great unified undertaking. The first stage of Wilton Works consists of the erection of 10 major manufacturing plants belonging to five of the company's divisions — alkali, billingham, dyestuffs, plastics, and general chemicals. The genesis of this undertaking makes interesting reading. On March 31, 1943 senior officials of the alkali, billingham, dystuffs and general chemicals divisions of the company met and discussed steps to be taken to site additional manufacturing capacity for its new and existing chemical products. The products considered at the time were those based on salt, ammonia and hydrogen, a self-contained establishment housing processes for a number of I.C.I. divisions. The meeting concluded that if the company's policy called for an entirely new works then the mouth of the River Tees seemed the best location. At one stage it was intended to concentrate all the company's manufacture of heavy organic chemicals on the site, and a large part was to be played by a joint concern formed by I.C.I. and a leading oil company to crack oil and manufacture petrochemicals. This scheme for a joint company for oil cracking fell through early in 1947, and I.C.I. decided to go ahead alone, with the Billingham division taking full responsibility for the cracking project.

Following the formal inauguration ceremony of the Wilton project in September 1949, Lord McGowan, I.C.I.'s chairman, stated: "We chose the North-East because no other area . . . offered the same easy access to our essential raw materials and such easy egress for our finished products to all parts of the United Kingdom and the world — by road, rail and sea. . . . Here we have close, abundant supplies of coal and salt, adequate water, communications that are first class, a population of 350,000 from which to recruit our workers and, in addition, we have close by our Billingham factory, and the close proximity of these two chemical plants will be of the greatest advantage to both enterprises. . . . Each of I.C.I.'s existing plants is firmly based on at least one major activity, and here at Wilton we have decided to have two—the cracking of oil for the production of basic organic chemicals, and electrolysis of brine for the production of chlorine and caustic soda. At Billingham I.C.I. already have a considerable stake in the

Billingham works sulfate buildings and storage in foreground. Tower station and water gas plant in background.





Part of the Billingham petrol plant.

production of organic chemicals from the hydrogenation of creosote oil. The Wilton cracker extends this interest and will in fact supply the basic raw materials for a large new petrochemical industry."

The first of its kind in the world the Wilton cat cracker, constructed by M. W. Kellogg Company produces primarily large quantities of very pure ethylene for the company's chemical manufacturing operations. It also accounts for smaller quantities of motor gasoline and propylene. The latter gas will be further processed into isopropyl alcohol and its derivatives. In the first step of the process naphtha is charged to oil heaters. In the second step it goes on to the pyrolysis section where this reaction occurs in an insulated transfer line as super-heated steam is introduced to raise the temperature of the oil to about 1700 F. During this step ethylene is produced by cracking the paraffinic material in the naphtha. This mixture of hydrocarbons is then split into gasoline and lighter fractions in the primary fractionator forming step three. The gasoline fraction is debutanized, and then is treated with phosphoric acid to polymerize entrained olefins into polymer gasoline (step four). Gases from the primary fractionator, after removal of hydrogen sulfide, pass through a special process step, in which all moisture is removed to preclude icing during the later low-temperature fractionation operation. After leaving the dryers the vapors pass through a catalytic acetylene conversion step, which converts virtually all of this gas into ethylene. The mixture of gases is then piped to the recovery section, constituting step five, where the pure ethylene is separated from other constituents.

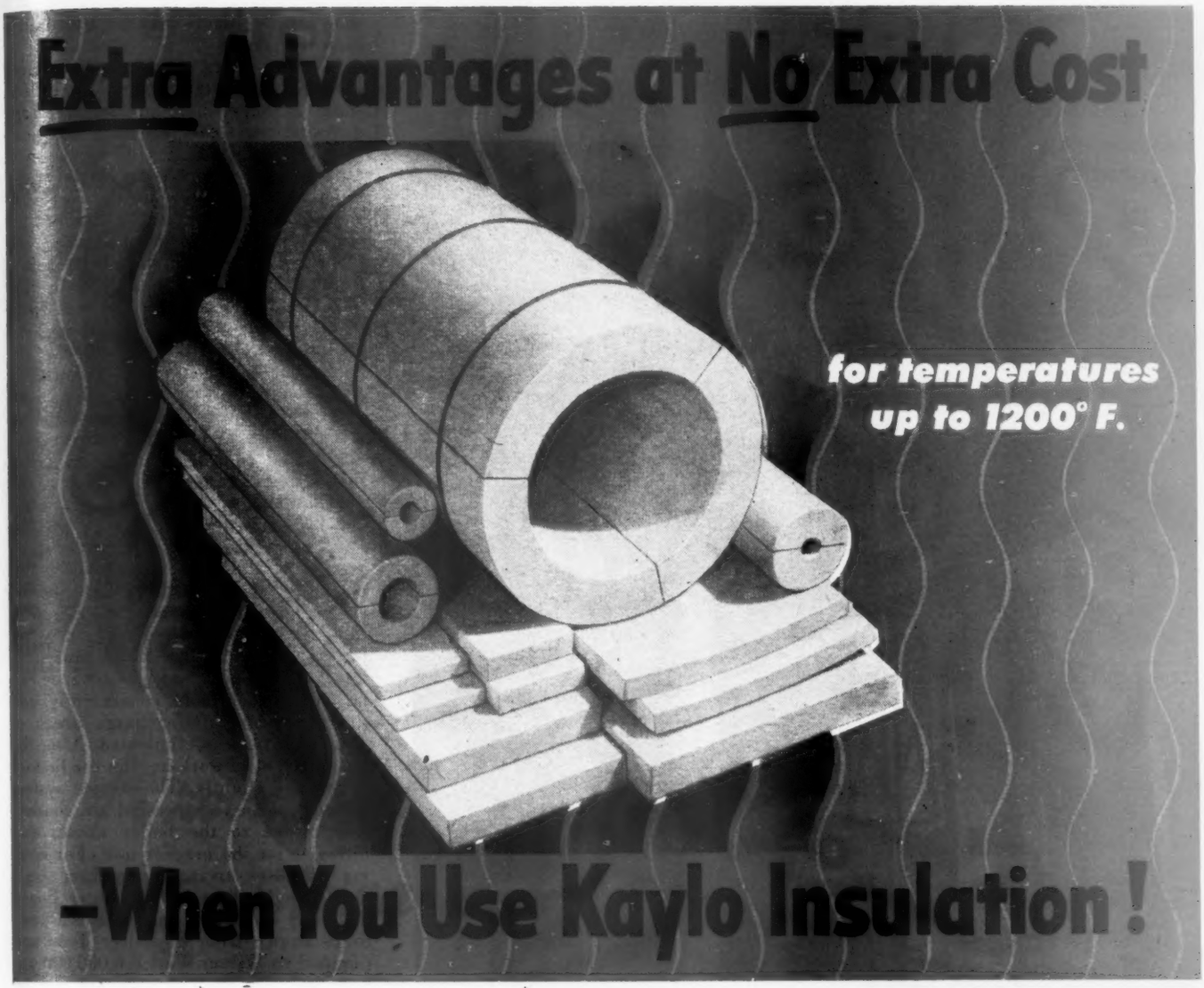
The initial objective is to work up only the C_2 (ethylene) stream at Wilton, the others being piped to Billingham for further processing there. The methane and hydrogen will partly replace water gas made from coke used for producing hydrogen. The C_3 (propylene) stream will be worked up to isopropyl alcohol, and then to acetone for which there is a substantial domestic demand. The C_4 (butane) stream will be partly sold as bottled gas, or blended with gasoline produced at Billingham, as will the gasoline from the cracker. The amount of heavy oils produced in the cracking will be relatively small and used as fuel for the cracker itself. Part of Wilton's ethylene will go to the polythene plant, where it will be subjected to the high pressure process discovered in the early 'thirties by the company. Some of the ethylene will be sent by tanker to other I.C.I. factories. The rest will go to a plant making ethylene oxide by the established chlorohydrin route, some of the oxide being hydrolysed to ethylene glycol for the domestic anti-freeze market. The remaining oxide will be worked up to Lissapol N, I.C.I.'s non-ionic detergent produced by the condensation of ethylene oxide and alkylated tar acid made at Billingham.

The company is already looking forward to several specific enterprises, which will lead to the erection of new plants at Wilton. Among these are the development of new chemical outlets for C_1 and C_4 streams from the cracker; extraction of various pure aromatics from the gasoline stream; development of additional ethylene oxide derivatives, and the working up of a propylene oxide-propylene glycol process analogous to the ethylene oxide process; devising of other processes to take advantage of the simultaneous availability of chlorine and organic chemicals from the cracker, and development of truly synthetic fibers, i.e. Terylene.

Beginning with ethylene Wilton is making polythene, Lissapool N, and anti-freeze. From propylene is prepared acetone, widely used as a paint solvent, and one of the raw materials of Perspex. Production of acetone is carried out at Billingham on the opposite bank of the Tees River, the Wilton propylene being sent there by a 10-mile long pipe line passing under that river through a tunnel 1750 ft long and 9 ft in diameter. This link will carry to Billingham various other hydrocarbons produced in the cracking plant, and also the gasoline. In the reverse direction will flow brine from the South Durham brine field forming the raw material for the electrolytic plant producing chlorine and caustic soda. Hydrogen gas is formed as a byproduct of chlorine manufacture. The bulk of it will be sent to Billingham, but a portion will be retained at Wilton for use in the production of alpha naphthylamine for the dyestuffs industry by an improved process.

When 2000 acres of land upon which Wilton Works is being built was originally bought the intention was to provide a site capable of accommodating a large part of the company's major developments for many years to come. These included not only additional plants for already well established products, but manufacture in quantity of the newer products brought to light recently and possibly completely new manufactures that may arise out of the company's researches. The first stage of the Wilton project is so designed

Extra Advantages at No Extra Cost



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—When You Use Kaylo Insulation!

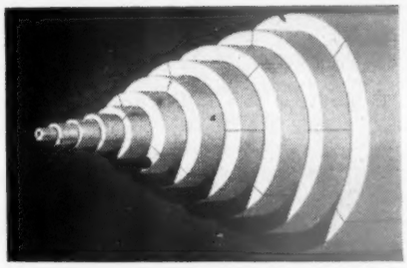
For example, Kaylo Heat Insulation reduces inventory requirements because:

1. Wide effective temperature range —up to 1200° F.—eliminates the need for combination coverings in nearly all operating conditions.
2. Simplified Dimensional Standards allow nesting.
3. Unmatched selection of shapes and sizes reduces the number of pieces required per job.

Kaylo Heat Insulation reduces installation costs because:

4. The material is lightweight, strong and easily handled.
5. It is easy to cut and fit with standard tools.

Kaylo Heat Insulation is a hydrous calcium silicate—the heat-saving material that is revolutionizing insulation practice with its outstanding combination of advantages. Get all of the facts now.



Simplified Dimensional Standards mean that O. D.'s of insulation correspond to O. D.'s of standard pipes, assuring proper fit for nesting, when necessary. With this system of snug nesting, Kaylo Heat Insulation assures fits for all operating conditions, requires less items—reduces inventory stocks.

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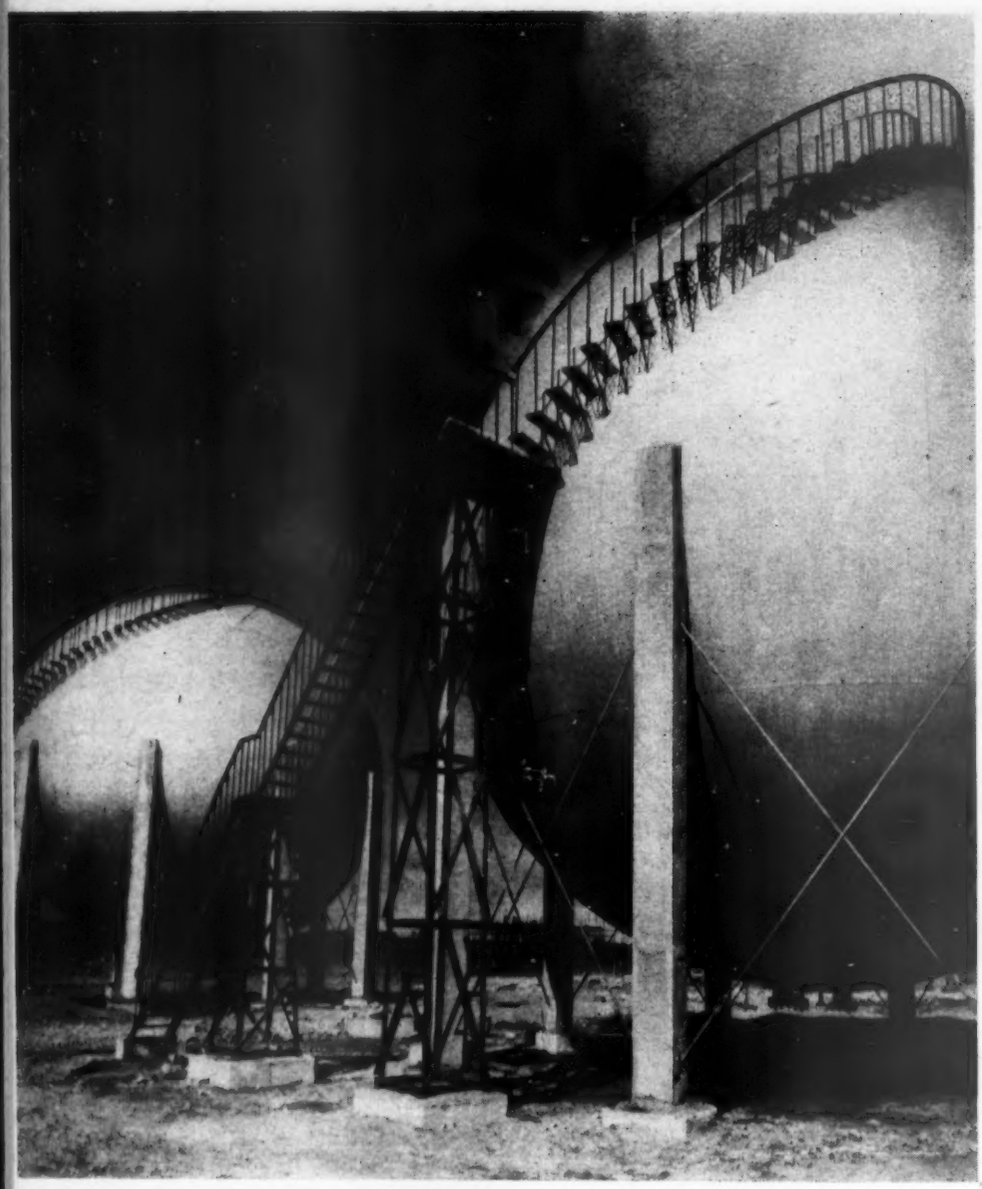
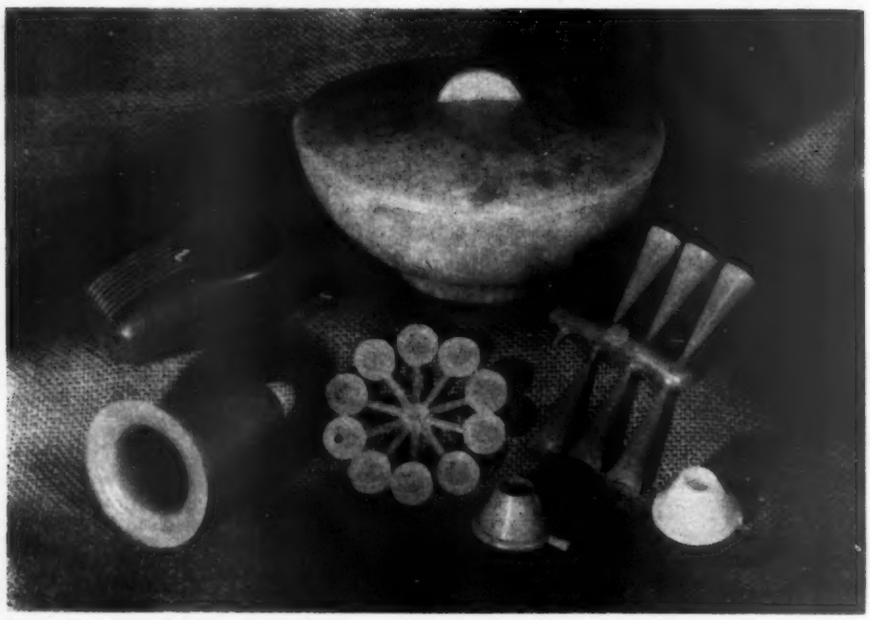


Two vessels for storing gas under pressure.



Samples of polythene injection mouldings.

that further plants may be added in a logical manner.

Most processes at Wilton are carried out at fairly high temperatures, and some at very high pressures. Large quantities of steam are used for heating raw materials, and although much of this heat is recovered, plenty of water is employed in removing the rest of it. Electricity is needed for driving the motors of compressors, pumps, and other machinery and the plant electrolyzing brine. Gas is required for heating in some of the processes, for heat treatment furnaces, in the workshops, etc. On completion of the first stage of the project about 500 tons of coal will be consumed each day in the boiler house, and steam raised at a pressure of 900 psig. Before being sent out into the network of pipes feeding steam to the plants it will be passed through turbo-alternators to generate most of the 30,000 kw of power required for production. The piping system through which services are distributed to manufacturing units is laid in shallow trenches and not supported on overhead steel gantries in contrast to Billingham and other large chemical factories. This procedure has the advantage that maintenance can be carried out more conveniently and the need for painting large areas of structural work is eliminated. Also, the amount of steel work used in the factory is reduced slightly. The service system includes steam, compressed air, condensate return to the boiler house, and nitrogen for the cracker unit. For cooling purposes arrangements have been made by the Tees Valley Water Board to supply 42,000,000 gal of water a week to be drawn from the River Tees and pumped to Wilton Works' 6,000,000 gal reservoir through 13 miles of mains. Other water requirements will be about 5,000,000 gal a week of purified water from the T.V.W.B. mainly for boilers. All drains lead eventually into a main drainage culvert of 7 ft diam, which passes under a trunk road through a narrow strip of land known as the "Corridor" to the Middlesbrough-Saltburn railway, under the railway, and across to the foreshore at Bran Sands. For transport of raw materials and products to and from the factory an extensive road and railway system is being constructed, including over 10 miles of roads and 15 miles of railways. Eight miles of the latter will lie in an area of upwards of 100 acres reserved for the Wilton Works main sidings.

The Perspex and phenol-formaldehyde moulding power plants came into commission in 1949. Construction work on the oil cracking plant and on the pipe line link between the Wilton and Billingham factories was virtually completed at the end of the following year. In 1950 the Tees Conservancy Commission oil wharf at Teesport was opened and initial cargoes of oil were discharged and pumped to the Wilton factory. Plants producing polythene, formaldehyde, a-naphthylamine, ethylene oxide, ethylene glycol, and Lissapol N detergent came into operation in 1951.

A room with a view... toward the future!

Plant superintendents and maintenance engineers MUST look to the future. They have the tough job of handling *today's* problems and anticipating tomorrow's. For instance . . . if a heat exchanger is showing signs of excessive corrosion the maintenance superintendent must see that repair or replacement is made BEFORE prolonged shut-down becomes necessary. It's a tough job and that's why many of these men have come to rely on Western Supply Company for assistance in all heat transfer problems. Western offers the trained help of an experienced staff of heat exchanger engineers to consult with YOU on all YOUR heat transfer problems. It is this SERVICE plus Western's close adherence to rigid engineering specifications that have made the big Western "W" a familiar trademark in refining and processing plants all across the nation. The NEXT time . . . CHECK WITH WESTERN.

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Satisfactory progress is being made on the chlorine plant, the first unit of which is scheduled to come into operation towards the end of this year. Late in 1950 I.C.I. announced its decision to erect a full-scale commercial Terylene fiber plant with a capacity of 11,000,000 lb per annum at Wilton Works. It is the company's intention that all stages of its manufacture from the raw materials to the finished fiber should be carried out at Wilton, which will involve the Billingham division in the production of raw materials, the Dyestuffs Division in the manufacture of intermediates and polymer, and the Plastics Division in the spinning of fibers from Terylene polymer.

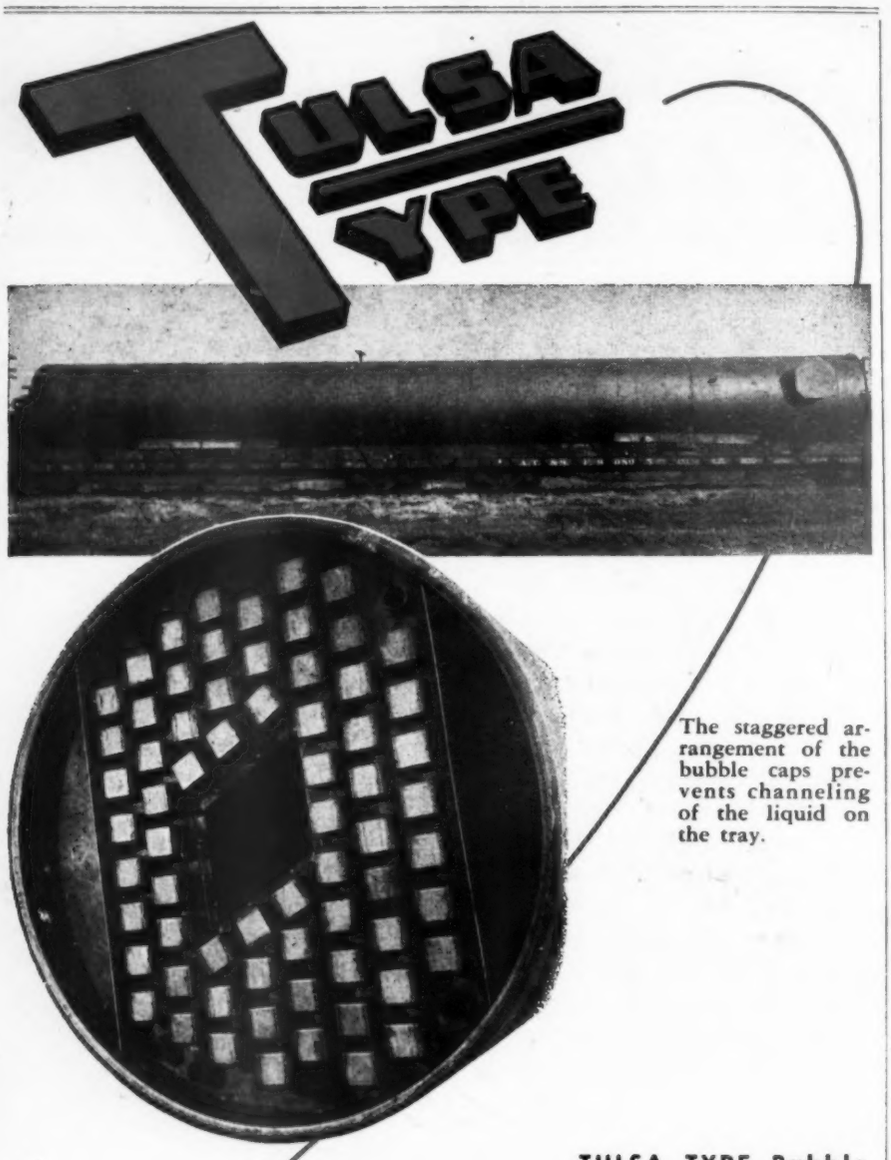
The process used in the Wilton Perspex plant incorporates the latest developments in mechanical and automatic control to increase productivity. The starting material is methyl methacrylate made by the company's general chemicals division at Billingham and Darwen (Lancashire). It is first partially polymerized by heating in the presence of a catalyst, and where coloured sheet is required pigments are incorporated at this stage. This syrup is poured into a mould formed by two glass plates and a flexible gasket, the gasket diameter and weight of syrup depending upon the required thickness of the final sheet. The gasket is of sufficient flexibility to take up the large contraction occurring during polymerization. The casting chamber is kept at a slight positive pressure with filtered air to insure freedom from dust in the air. The filled moulds are mechanically loaded onto trucks, which then pass to a battery of 6 automatically operated and controlled hot-air heated ovens. At the end of this stage of the process the glass adheres tightly to Perspex sheet, and a special stripping operation is necessary to facilitate separation. This operation is also automatically controlled, and the time and temperatures employed in both polymerization and stripping processes are chosen to suit the thickness and type of sheet being produced. On removal from stripping ovens the glass moulds are mechanically unloaded from the trucks and Perspex sheets removed. The glass is again in position for mechanical washing and re-use. Each Perspex sheet is individually examined for contamination, distortion, and color, and subjected to a variety of quality control tests to ensure that quality is of the standard required for the intended applications.

No account of Wilton would be complete without reference to the Billingham factory on the other side of the Tees. The great coal hydrogenation plant began operation there in 1937 and accounted for more than 100,000 tons of gasoline a year. During that emergency it was producing superior aviation spirit to feed the Royal Air Force planes. The hydrogenation process, incidentally, gives rise to a number of valuable by-products, especially tar acids shipped for use in the manufacture of plastics, disinfectants, dyestuffs, and medicinal chemicals. The Billingham works is the largest chemical factory in the British Empire, and the second largest in the world. It occupies a site of about 1000 acres, and is 7 miles in circumference. It accounts annually, for about 1,250,000 tons of products vital to national economy, ranging from fertilizers to high-grade gasoline. The Billingham-Wilton set-up will make the twin complex the world's largest chemical unit.

The staff at Wilton Works is a composite one, drawn one-fourth from the I.C.I., and three-fourths from outside the company altogether. Last August employees at Wilton numbered some 2000 factory workers and 450 staff. By 1953 it is reckoned that these numbers will grow to 4250 and 600 respectively, and it is expected that about 2000 contractors' men in addition will be employed on the site. * * *

Benzene Output May Double

The nation's supply of benzene will soon be doubled thanks to increased production from petroleum sources, due to a new process for recovering benzene, developed by Shell Development Company. The petroleum industry increased benzene by cracking and reforming petroleum to produce stocks richer in benzene and other aromatics. The new process can be applied to these stocks to produce chemical-grade benzene.



The staggered arrangement of the bubble caps prevents channeling of the liquid on the tray.

TULSA TYPE Bubble Towers are BUILT RIGHT to accomplish the processing function required.

FLINT STEEL CORPORATION
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FIG. 1. This spreading tool compresses insulation until all the strips have been inserted. When it is released strips spring back and fill the jacket within the flange.

FIG. 2. Surface of the insulation being sandpapered before cut-outs are made.

Self-Retaining Mineral Wool Boards

Ease of access for inspection and maintenance increases the value of removable insulation

MAINTENANCE of heated vessels is greatly simplified by snap-on insulated jackets that are easily removed for access to operating sections of equipment. Mineral wool boards are wedged into a framework of metal jacket segments, without the need for further attachment, to form highly efficient, rugged insulating units.

The Badger Manufacturing Company of Cambridge, Massachusetts, applied this technique in insulating the evaporated sections of vapor-compression distillation units being produced for the U. S. Navy. The distillation units process sea water to make it palatable for human consumption on board ships powered by internal combustion engines

FIG. 3. This cut is necessary to fit around a flange on the distillation unit. Vertical cut is made first.

FIG. 4. Completed jackets ready for assembly. One jacket of each type is required for every distillation unit.

—submarines, patrol boats, mine sweepers, landing craft, floating workshops, and similar auxiliary vessels. Distilling units are made in two sizes capable of handling 50 and 1000 gal per hour. The operating temperatures of the lower section of the insulated evaporator unit range between 230 F and 240 F and the upper section operates at about 216 F.

Each evaporator unit is covered by two insulating jackets that may be removed separately for access to either the evaporator's upper or lower section. Of similar design, both insulating jackets consist of three 120-deg segments that are rapidly fitted together around the evaporator and secured by snap locks.

The basic insulation installed on the jacket for the lower evaporator section is 3-in.-wide strips cut from 24 by 48-in. mineral wool boards, 1 in. thick. Application of insulation in the upper evaporator section is similar to the method described in detail for the lower sections.

Strips of insulation are first inserted on their 1-in. edges in each 120-deg segment of the lower sections and pressure applied with a special spreading tool (Fig. 1). After the proper number of strips have been inserted, an even tension is produced which retains the 3-in. thick insulation in place without need for any external means of fastening. The density of the mineral wool board is increased slightly when the strips are installed in the jacket segments.

The inside surface of the self-retaining insulation is then sandpapered to provide a close fit when in position on the evaporator (Fig. 2). The insulation is cut according to specifications in order that the jackets fit over flanges in the evaporator unit and allow connecting pipes to pass (Fig. 3).

In Fig. 4, a complete insulating jacket for the lower evaporator sections rests on an assembled jacket for the upper section. Note the smooth surface and sharply-defined contours of insulation.

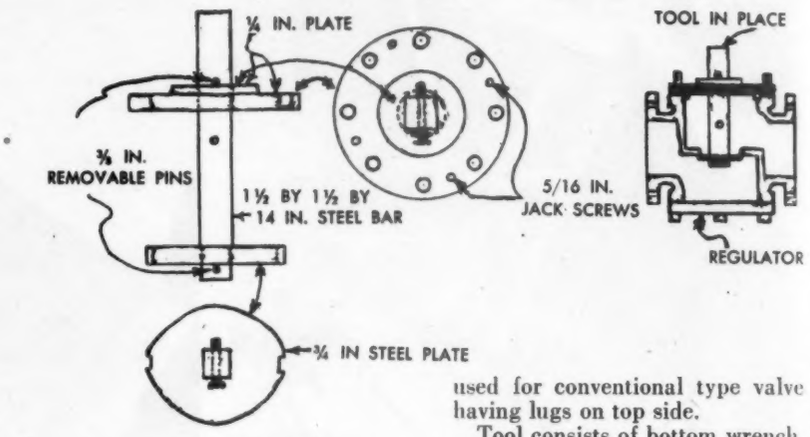
In the operation of the distilling unit scale forms on heated surfaces and must be removed at regular intervals. In distilling sea water, the quantity and character of the scale are such that operating cycles of 700 hr between cleanings are possible. The scale, deposited on the tubes, is relatively pure magnesium hydroxide and is removed by an acid salt treatment which requires about two hours' time. The removable type of jacketed insulation permits easy access to the interior of the evaporator for maintenance and inspection.

This installation technique is adaptable in such industries as chemical or food processing and petroleum refining to the insulation of many types of high-temperature vessels having a similar uniform curvature. ★ ★ ★

"I think that the oil industry is enjoying the best reputation from the point of view of public relations that you have had in my lifetime. I think it is deserved. I think you have worked for it. I think you are honestly trying to do it, and I want to see it continue. I want us all to work together."—Oscar Chapman, Secretary of the Interior.

Tool to Remove Valve Seats*

W. L. RANDALL† and E. T. BUCKLEY‡



Purpose: To remove and/or replace valve seats in pressure operated regulators while valve body is in line.

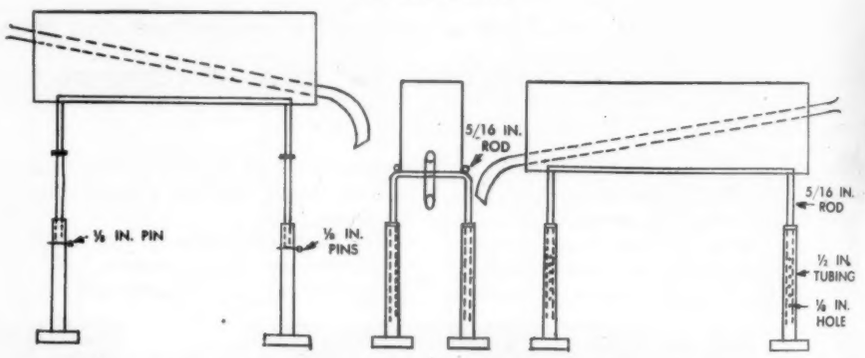
Tool was especially designed to remove seats having lugs on under side of seat but which are still removed through top side of regulator. It may also be used for conventional type valve seats having lugs on top side.

Tool consists of bottom wrench, elliptical in shape, to allow passage through valve seat, after which it is attached to extension bar by means of removable pins. Top part of tool consists of plate and washer on upper end of extension bar, and drilled to fit bolts of valve body top works. Jack screws are also in top plate to take up slack. By applying pressure to upper end of extension bar, seat may be removed or replaced.

*Class A, third prize at NGAA.
†Machinist and ‡repairman, United Gas Pipe Line Company, Carthage Gasoline Plant, Carthage, Texas.

Adjustable Stand for Distillation Equipment#

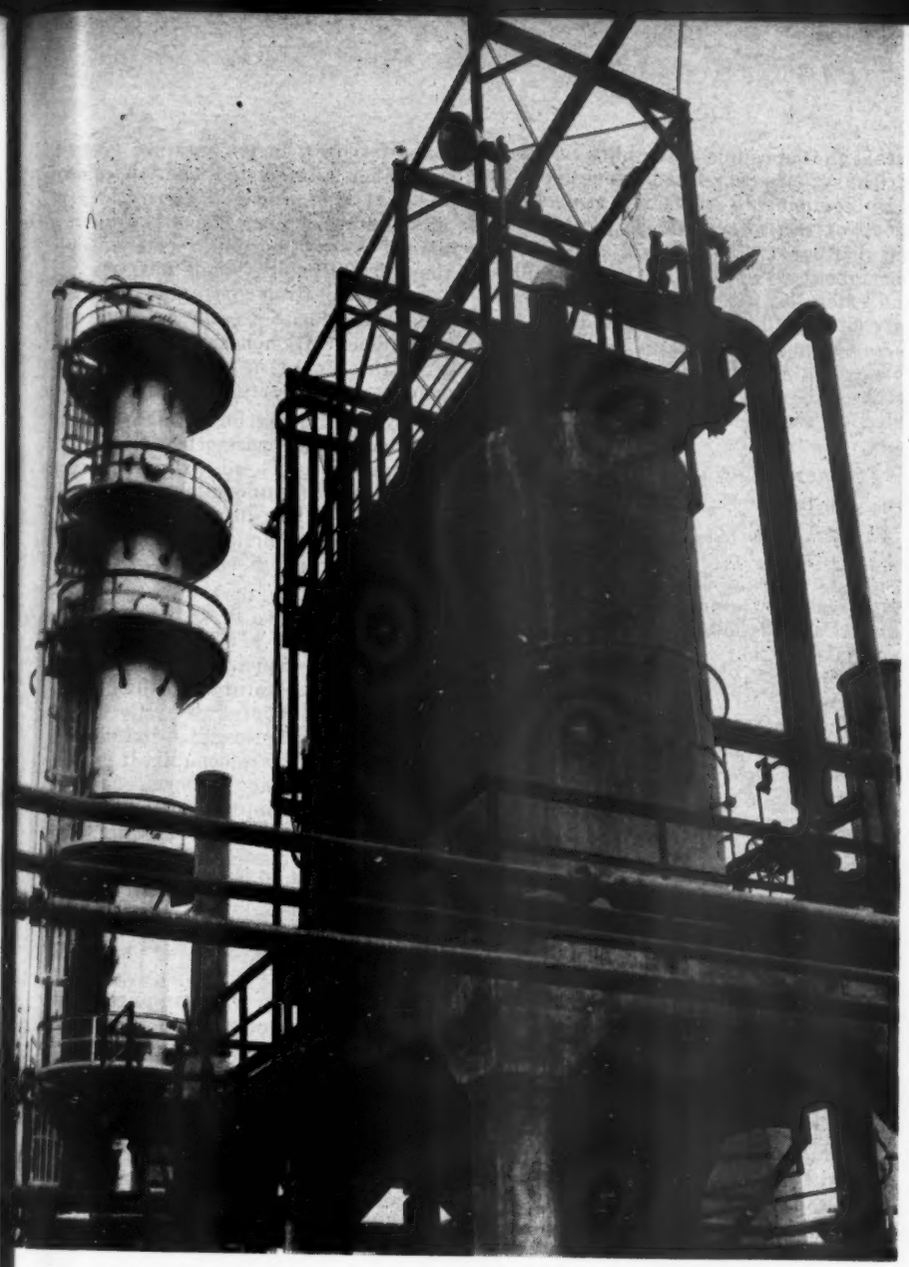
L. L. POTTHOFF§



Purpose: To prevent breaking vapor tube on flask and make the apparatus easier to handle.

The following apparatus must be available for running a distillation test on natural gasoline and petroleum products such as distillate or heavier. Flask, condenser, shield, ring supports, asbestos board, and graduate. After the sample has been transferred to the flask, it is very easy to break the vapor tube when connecting the flask to the condenser tube, if you are not careful, because all of the equipment (shield ring support, and condenser) is stationary, and the glass is very fragile. The stand has been reconstructed and rearranged by using 5/16-in. rods for the top part of the stand and leaving the leg approximately ½ in. in diameter. A hollow tube is constructed to fit over the bottom of each leg. The tube being hollow allows the legs of the stand to be inserted. The hollow tube has small holes drilled horizontally, to allow places for pins to be pushed through. By this means, the stand can be raised or lowered for any particular distillation, whether it be a natural gasoline sample, or a heavy oil sample; thus making a perfect fit between the flask vapor tube and the condenser tube. The base of the stand tube is constructed so as to give a good footing. It has been noted in the equipment that was purchased from laboratory concerns, that when the condenser was placed on the stand, the condensate dripping off the condenser has a tendency to make the stand rust, due to the construction of the purchased stands, which have flat places on top where water may accumulate. By having the rods the water readily rolls on down and can be wiped up after the test has been finished. It can be cleaned very quickly. We have found that the new constructed adjustable stand makes a nicer piece of laboratory equipment and has saved many flasks from being broken.

#Class B honorable mention at NGAA.
§Plant chemist, Warren Petroleum Corporation, Gladewater, Texas.



View of two catalyst chambers in an oil refinery showing thermocouples with weatherproof heads installed on wall and conduit ring for extension wire.

Refinery Instrumentation

PART 4 — Thermocouples and Extension Wire

S. D. ROSS* and J. PROCOPI*

FEW refinery personnel, even those having only the vaguest association with instruments, are unacquainted with the "mighty midget" — the *thermocouple*. Almost everyone in the plant is at least aware that this temperature-sensing element develops a small voltage in relation to the temperature of the process vessel into which it is inserted. Yet beyond this simple operating principle lies much important information which instrument engineers in a refinery must know to assure accurate, reliable, and reproducible temperature measurements as well as minimum maintenance with thermocouple pyrometers.

Although notable advances have been made in the last decade in recording, indicating, or controlling instruments used to measure temperature, the thermocouple today remains essentially the same and has the widest useful range of any temperature measuring element—from −300 F to about +3000 F. It is true that the resistance thermometer bulb has been better adapted in recent years to industrial use and offers certain advantages for specialized applications, but the thermocouple is still today the "workhorse" of temperature measuring means in the refinery.

At first glance, with the basic simplicity of a thermocouple, one might wonder what factors are so important as to require elaborate discussion in a full-length article in this series. Further consideration, however, will reveal these applicational requirements for the thermocouple:

1. It is installed directly in the process medium which can be corrosive and at high temperatures or pressures.
2. The accuracy and reliability of temperature measurement *and control* is entirely dependent upon the thermocouple.
3. Literally hundreds of temperature points are measured by thermocouples in a refinery, representing a sizable maintenance responsibility even when a minimum of attention is required.
4. To a large extent thermocouples are expendable and the cost of their replacement must be minimized by proper protection and care.
5. A thermocouple involves basically an electric circuit with connections hundreds of feet in length to remote panelboards—failure of these connections *at any point* means failure of the entire instrument system and consequent loss of automatic recording and control for the refinery operation involved.

The value placed upon the thermocouple and its associated parts is evidenced by the attention it has received recently from the Instrument Society of America which has published five Tentative Recommended Practices covering this subject[18]. In fact, when one considers the aspects of installation, fabrication, calibration, checking procedures, and maintenance, it becomes impossible to cover all the available data on this subject in one article. An attempt is made herein to highlight the essential points with an eye toward the selection and maintenance factors.**

Basic Principles of Thermoelectricity

Because it is fundamental to a proper understanding of thermocouple selection, installation, and maintenance, a brief review of principles is given here before the more pertinent phases of the subject are covered. Numerous references commonly available in the instrumentation field cover these principles in detail and are studied in most instrument courses.[7a, 12, 13, 14, 15, 16]

Basically, a thermocouple is composed of two dissimilar metal wires joined together in a circuit such as illustrated schematically in Fig. 1. A small d-c voltage is produced by the difference in temperature between the

*Brown Instruments Division, Minneapolis-Honeywell Regulator Company.

**Part 5 covers thermocouple fabrication and calibration.

EXCLUSIVE

measuring junction (or *hot junction*) which is the point of measurement, and the *reference junction* (or *cold junction*).

The magnitude of the emf[a] developed by a thermocouple is of the order of from 3 to 17 millivolts at 600 F, as shown in the graph of Fig. 2 for common thermocouples. From the graph, also, it is seen that this emf increases fairly linearly with the measured temperature and has a different curve for different combinations of metals. Since the developed emf would obviously vary if the reference junction temperature varied, these curves (and most instrument manufacturers' tables) are based upon the standard reference junction temperature of 32 F.

Fig. 3 illustrates schematically the incorporation of a thermocouple into a thermoelectric pyrometer system as it is used most commonly. The basic components are seen to comprise (1) the *thermocouple* connected to (2) a *terminal head*[b] which is located near the point of measurement and is in turn connected by (3) *extension wires to* (4) a *pyrometer* which incorporates (5) *internal extension wire* and (6) the thermocouple *cold junction*. It will be noted that the thermocouple cold junction is *extended* to the instrument which usually contains a temperature sensitive resistor in the circuit to compensate for minor changes in the cold junction temperature.

In addition to these basic components, actual thermocouple assemblies and installed systems contain additional necessary components such as *protecting tubes or wells, ceramic insulators* on the thermocouple wires within protecting tubes, *insulation* on thermocouple and extension wires, and certain accessory fittings for installations. Each of these components plays an equally vital role which will be discussed in detail later with a view toward practical selection and maintenance problems.

[a]emf = Electromotive force.
[b]Termed "Connection Head" in ISA terminology (RP1.3[18c]).

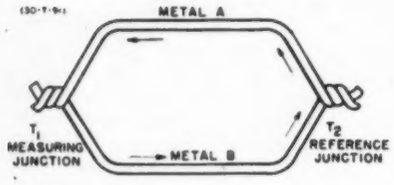


FIG. 1. Simple thermocouple circuit.

General Qualifications for Suitable Thermocouples

Of the many metals and their combinations, the five pairs shown in the graph have been adopted for one or more reasons to suit the needs of industrial applications. In the selection of materials for thermocouple use the following important qualifications must be considered:

1. The thermocouple materials must be reasonably resistant to corrosion, oxidation, reduction, and crystallization —often at high temperatures.
2. A comparatively large emf change with temperature should be developed by the thermocouple.
3. The temperature-emf relation should be as linear as possible over the temperature range for the thermocouple.
4. The materials employed should be readily reproducible so that uniform accuracy can be obtained and interchangeability permitted.
5. The cost of the materials should be moderate.

Many thermocouple materials tried in the past have been discarded because of the first qualification. Actual limitations of the five thermocouples in this respect are considered under the discussion of each under "Common Types of Thermocouples".

The need for a comparatively large emf should be obvious when it is considered that the largest emf produced by any commercial thermocouple at the upper limit of its usable temperature range is about 50 mv or only 1/20 of a volt. Moreover, in temperature control, the refiner is interested in measurement of *changes* in process temperatures of only several degrees which represent a change in thermocouple emf of only about 0.0001 volt (about 0.03 mv per degree F for iron-constantan at about 600 F). Even with present-day electronic potentiometers, such small voltages require the utmost in precision measurement and sensitivity.

The requirement for a relatively uniform increase of thermocouple emf with temperature is based primarily upon the desire for a uniform chart and scale calibration of the instrument. In addition, reference-junction compensation is accomplished more easily.

Reproducibility of thermocouples is of vital importance in the practical use of thermoelectric pyrometers in the refinery. The pyrometer is calibrated in degrees of temperature and the graduations on the chart or scale apply for one definite temperature-emf relation and for one type of thermocouple. It is often necessary to replace a thermocouple in service and the interchangeability factor then becomes almost essential. This factor applies equally well when a number of thermocouples are connected to one indicator or a multi-point recorder.

As regards reproducibility with present-day thermocouples, we have the metallurgist to thank for the availability of much higher standards in pure metals and alloys as compared to the earlier days of pyrometry. This, combined with the closer matching of thermocouples by instrument companies, has made possible much better accuracy statements for all types of thermocouples.

Little need be said about the qualification of moderate cost for thermocouple materials that is not obvious to the refinery man. Varying greatly with the application, the replacement rate of thermocouples can be quite high and the unit cost becomes proportionately a more important factor. This is one obvious limitation to the use of platinum thermocouples.

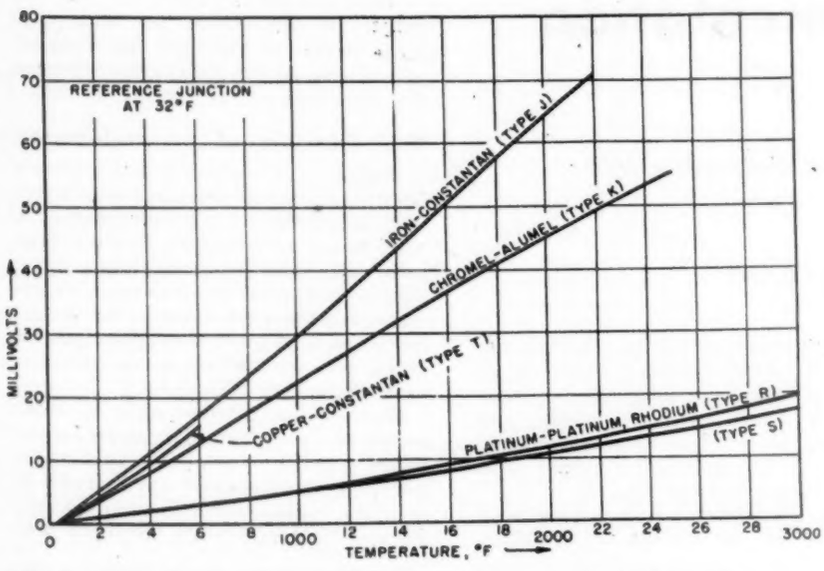


FIG. 2. Curves of emf versus temperature for five common thermocouples.

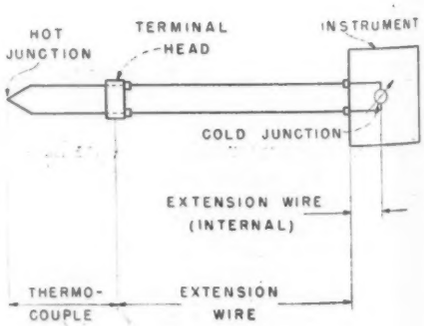


FIG. 3. Schematic circuit diagram of a thermoelectric pyrometer system.

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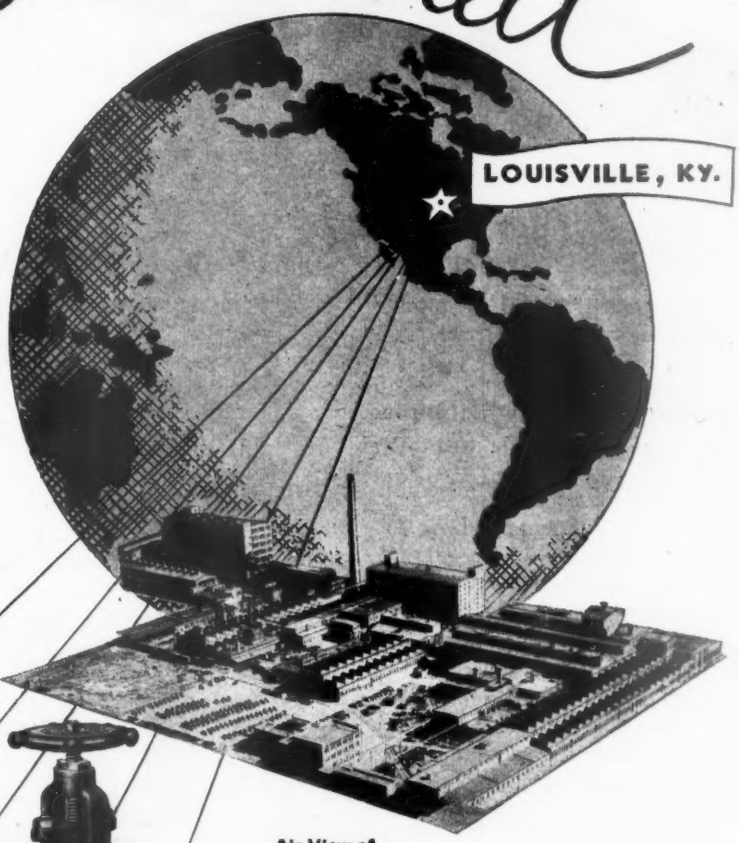

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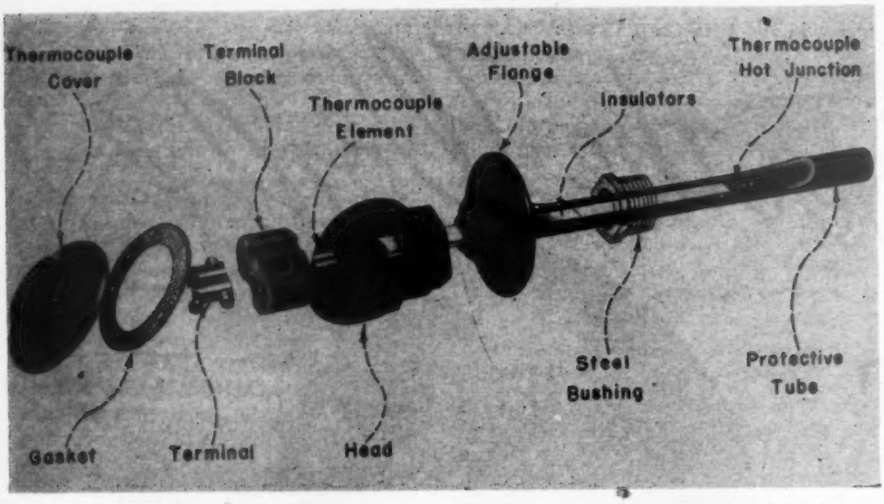

FIG. 4. Exploded view of a typical industrial thermocouple assembly.

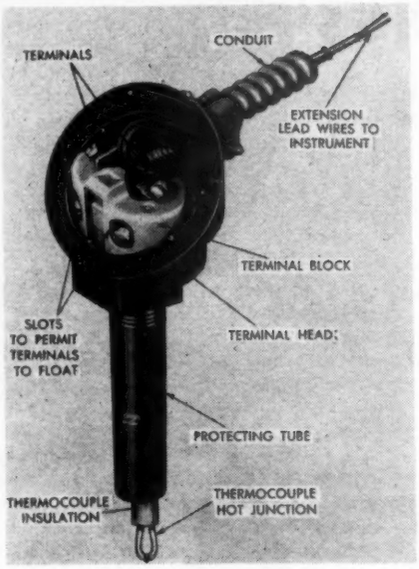

FIG. 5. View of thermocouple assembly with terminal head cover removed.

Common Types Thermocouples

The five most commonly used thermocouples are:

Base Metal Thermocouples

(1) Copper-Constantan (Type T)
(2) Iron-Constantan (Type J)
(3) Chromel-Alumel[c] (Type K)

Noble Metal Thermocouples

(4) Platinum, 13 per cent Rhodium-Platinum (Type R)
(5) Platinum, 10 per cent Rhodium-Platinum (Type S)

The type letters in parenthesis after each are the letter symbols adopted by I. S. A. in 1948[18a]. The graphs of Fig. 2 illustrate the general temperature-emf relationship for the five thermocouples but accurate values can best be obtained from tables available from the Bureau of Standards and thermocouple manufacturers. Fig. 6 charts the useful temperature range of these thermocouples which are discussed in detail below, while Table 1 gives typical limits of error which are seen to be related to the temperature range.

Copper-Constantan (Type T). These thermocouples have a pure copper wire for the positive conductor and a copper nickel (Constantan) alloy for the negative conductor. They are particularly well suited for measuring temperatures from −300 F to +600 F, and are low in cost. Their resistance to corrosion due to atmospheric moisture or moisture condensation, which frequently occurs in the measurement of sub-zero temperatures, is an outstanding advantage.

In general, Copper-Constantan thermocouples can be furnished with a higher degree of accuracy from sub-zero temperatures to +300 F than any other commercially available thermocouple. Originally used primarily in the laboratory and pilot plant, they are now being employed more and more industrially for low temperature work, and can be used in either oxidizing or reducing atmospheres in their recommended temperature range.

Iron-Constantan (Type J). These thermocouples use iron for the positive conductor and Contantan for the negative conductor. They are applied normally for temperatures from about 0 to 1400 F, and are suitable for use in oxidizing or reducing atmospheres. They are relatively low in cost and therefore have become quite popular for applications within their recommended temperature range.

Chromel-Alumel (Type K). The Type K couple comprises a positive conductor of a nickel-chromium alloy and a negative conductor of nickel-aluminum alloy. It is generally recommended for temperatures from 1000 to 2000 F, although an upper temperature limit of 2300 F is given by I. S. A.[18c] Best service is obtained when this couple is used in oxidizing atmospheres, but it can be used in reducing atmospheres or atmospheres that are alternatingly oxidizing and reducing, if it is supplied with a suitably ventilated protecting tube.

Accuracy guarantees for Chromel-Alumel thermocouples have improved considerably in recent years and they have a very uniform temperature-emf relationship. They complement nicely Iron-Constantan couples in coverage of the range of temperature measurements, but their cost is somewhat higher (although not sufficiently so to discourage their wide use).

Platinum-Platinum, Rhodium Thermocouples (Types R and S). These thermocouples are made up of a pure platinum negative conductor, and a positive conductor of either 87 per cent platinum and 13 per cent rhodium (Type R) or 90 per cent platinum and 10 per cent rhodium (Type S). Suitably protected, they are recommended for temperature measurements up to about 2900 F in oxidizing atmospheres and to about 2700 F in reducing atmospheres. They are easily contaminated; thus

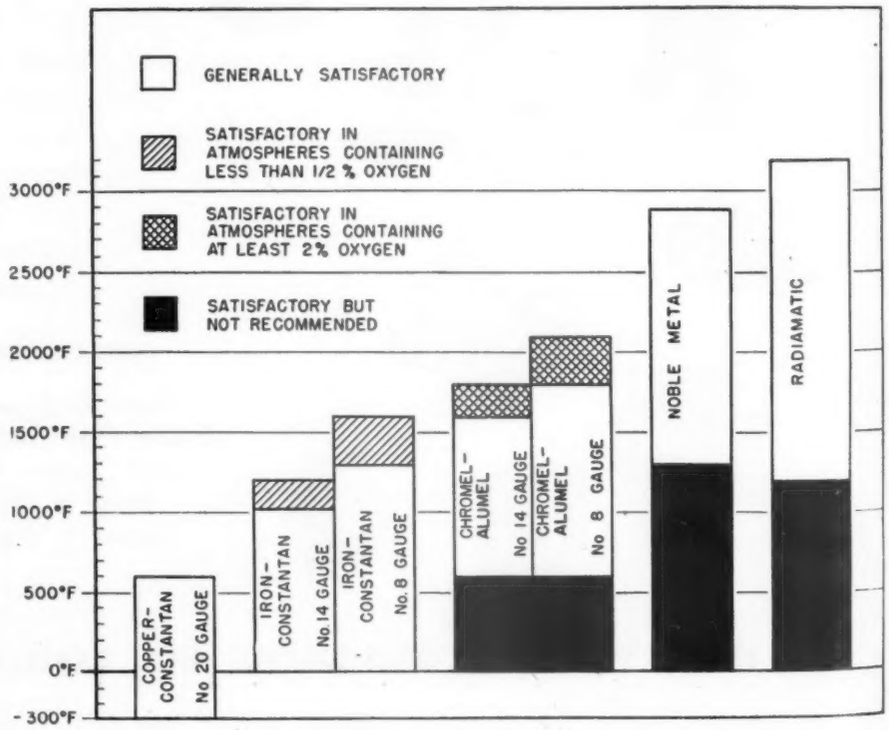

FIG. 6. Useful temperature ranges of industrial thermocouples.

[c]Trade-Mark Registered Hoskins Corp.

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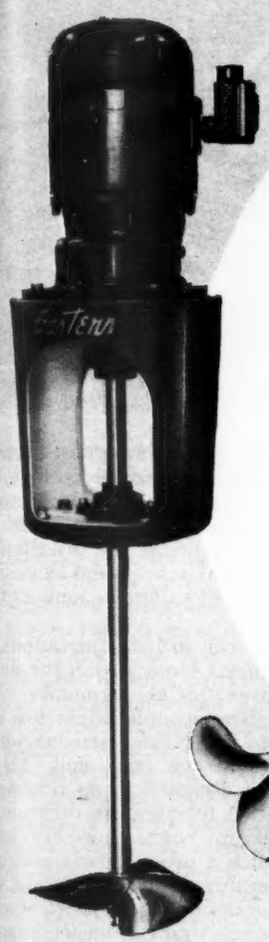

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must always be used with protecting tubes. Silicon, particularly, as well as hydrogen or metallic vapors will contaminate these couples. (Even the rhodium in the thermocouple wire can vaporize somewhat at high temperature and contaminate the companion platinum wire; thus a full length double-bore ceramic insulator must be used over the pair of wires.)

Because of their comparatively high cost and also the low emf produced, practical industrial applications of the Type R and Type S couples are limited to the measurement of temperatures beyond the range of Chromel-Alumel couples. Yet as a calibration standard noble-metal couples are used extensively because of (1) their high resistance to oxidation and reduction, (2) the high purity and reproducibility of the metals, and (3) freedom from parasitic currents or change in calibration. Their reliability is demonstrated by the fact that they have been adopted as the standard for the International Temperature Scale between 1220 and 1945 F.

Grades of Thermocouple Wire. To meet the different accuracy requirements of thermocouples, most manufacturers offer two basic grades of bulk thermocouple wire and thermocouples using this wire, namely: (1) Regular (or Standard) Grade and (2) Special Grade. (See Table 1.) Regular Grade wire follows the standard temperature-emf curve very closely and is suitable for most industrial applications; thermocouples made from this wire or the bulk wire can also be furnished with an error curve giving their deviation from the standard calibration at specific temperatures.

Special grade wire is specially selected to follow the standard calibration curve more closely and is used where better absolute accuracy is desired; its cost is slightly greater. Regular grade thermocouples can also be supplied with a National Bureau of Standards certification at a nominal charge when best accuracy is desired and use of a correction is not objectionable.

Thermocouple Wire Sizes and Insulation. As recently standardized by ISA,[18c] recommended wire sizes for thermocouples are as follows:

ISA recommended thermocouple wire sizes[18c].

Type of thermocouple	Wire size, B & S gage
Iron-Constantan, Chromel-Alumel	8, 14, 20, 24, & 28
Copper-Constantan	14, 20, 24, & 28
Platinum-Platinum, Rhodium	24

In general, smaller wire sizes are preferable for greater speed of response because of the smaller mass with a bare thermocouple or smaller diameter protecting tube. On the other hand, the life of the thermocouple increases with heavier gauge wires which more ably resist deterioration and contamination at elevated temperatures — factors which eventually cause a permanent shift in the thermocouple calibration. As will be noted from Fig. 6, the highest recommended temperature for each type of thermocouple decreases as the wire size decreases.

Matched pairs of insulated thermocouple wires (similar to extension wire) are available in limited wire sizes for applications where the refiner makes his own thermocouple, such as for peening on the surface of a pipe or vessel, and where the application does not require a protecting tube.

Such wires are usually run directly to the pyrometer, serving as extension wire as well. The type of insulation they employ is similar to that for extension wires, as described below.

FIG. 7. View of screw cover head and interchangeable terminal blocks. Left to right: below head are terminal blocks for (1) single thermocouple, (2) two thermocouples, and (3) resistance thermometer bulb.

Terminal Head (Connection Head)

The thermocouple *terminal head* (or *connection head* as it is identified now in standard terminology[18c]) should not be underestimated as one of the component parts of a thermoelectric pyrometer system. Proper attention to this element can assure the accuracy obtainable with the system and contribute to ease of installation and maintenance. Figs. 4 and 5 illustrate a typical *general purpose* head while Fig. 7 illustrates a *screw cover* type of head preferred in most refinery installations.

The purpose of the thermocouple connection head is twofold, namely: (1) to provide facilities for making electrical connections between the thermocouple wires and the extension wire, and (2) to provide means for attachment of a protecting tube, and the conduit usually used to protect the extension wire. These two purposes are rather self-explanatory; the first is important in most refinery applications where it may be necessary to replace the thermocouple and its protecting tube a number of times during the life of the installation while the connection head and extension wire are expected to last as long as the pyrometer.

As can be seen in the illustrations, a ceramic terminal block within the head contains large metal terminals into which the thermocouple wires are inserted and to which the extension wires are attached at the back end. These terminals are designed to be relatively massive so that temperature differences between the two connections are minimized; if such a precaution is not taken, a temperature difference might introduce a parasitic voltage which would affect over-all accuracy of measurement.

Although the general purpose head is provided with a gasketed cover which can be screwed down tightly on the head, the screw cover type of design (Fig. 7) is preferable for out-of-door installations where the head must be completely weatherproof. It employs the same terminal block construction as the other type head but, as illustrated, can be provided with other interchangeable types such as the block for twin thermocouples used for certain temperature measurements on catalytic cracking units. The head must be completely protected against rust; use of screw threads on the inside of the cover minimizes "freezing" of the cover to the base.

All types of connection heads are usually designed with terminal blocks that accommodate the various sizes of thermocouple and extension wires. Raised letters molded into the ceramic block to identify thermocouple polarity and type help assure proper connection of the positive and negative extension wires to their respective terminals.

TABLE 1. Limits of error of thermocouples.*

Type	Temp. range, °F	Limits of error: Standard	Special
Copper-	−300 to − 75	.....	±1%
Constantan	−150 to − 75	±2%	±1%
	− 75 to +200	±1½F	±¾F
	200 to 700	±¾%	±⅜%
Iron-	0 to 530	±4F	±2F
Constantan	530 to 1400	±¾%	±⅜%
Chromel-	0 to 530	±4F	..
Alumel	530 to 2300	±¾%	..
Platinum			
Rhodium-	0 to 1000	±5F	..
Platinum	1000 to 2700	±0.5%	..

* Taken from ISA RP1.3 18c

Extension Wire

Extension wire is generally furnished in the form of a matched pair of conductors with a type of insulation designed to meet the service needs of a

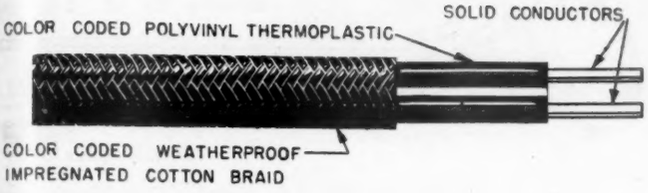

FIG. 8. Polyvinyl plastic insulated extension wire with over-all weatherproof braid.

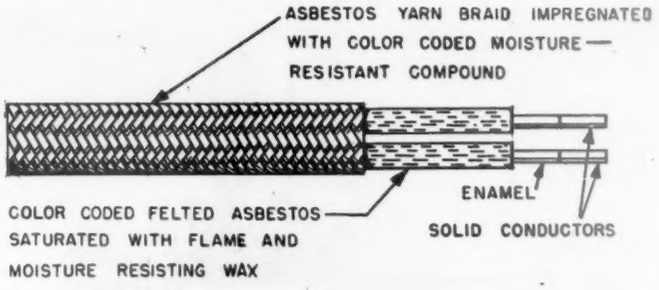
ASBESTOS YARN BRAID IMPREGNATED WITH COLOR CODED MOISTURE RESISTANT COMPOUND
ENAMEL
COLOR CODED FELTED ASBESTOS SATURATED WITH FLAME AND MOISTURE RESISTING WAX
SOLID CONDUCTORS

FIG. 9. Enamel and felted asbestos insulated extension wire with over-all asbestos yarn braid.

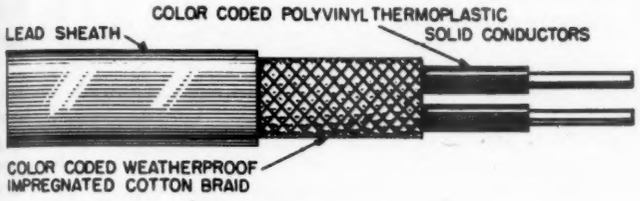
LEAD SHEATH
COLOR CODED POLYVINYL THERMOPLASTIC SOLID CONDUCTORS
COLOR CODED WEATHERPROOF IMPREGNATED COTTON BRAID

FIG. 10. Polyvinyl plastic insulated extension wire with over-all braid and lead sheath.

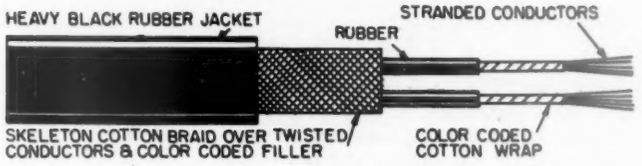
HEAVY BLACK RUBBER JACKET
RUBBER
STRANDED CONDUCTORS
SKELETON COTTON BRAID OVER TWISTED CONDUCTORS & COLOR CODED FILLER
COLOR CODED COTTON WRAP

FIG. 11. Flexible extension wire with stranded conductors and rubber insulation and jacket.

particular installation (see Figs. 8, 9, 10, and 11). Basically, the simplest procedure with extension wire would be to use the same types of wire from which the thermocouple itself is made. In actual installations, however, where several hundred feet of extension wire must be run from a couple and numerous couples are used, this becomes somewhat more expensive with Chromel-Alumel and prohibitively expensive Platinum-Platinum, Rhodium couples.

Certain basic data regarding extension wires are covered in Table 2, namely: (1) types for various thermocouples, (2) ISA recommended symbols and color code for duplex insulated wire, (3) limits of error as established by ISA, and (4) resistance in ohms per double foot for 16 gage wire. The Tentative Recommended Practices give much additional good data.

Recommended Wire Sizes. As recently standardized by ISA for all types of extension wire, only No. 14 and 16 B & S gage wire are recommended to be employed. The major factor here is the affect of the external resistance upon operation of the pyrometer. A millivoltmeter is more affected and may have to be recalibrated if considerable resistance is involved, although newer types designed for high resistance circuits are not so easily thrown off calibration. Electronic potentiometers, on the other hand, are affected very little by external resistance and can actually use wire as small or smaller than 20 gage.

Accuracy of Extension Wire. Since extension wire theoretically merely "extends" the cold junction to the instrument, it may not be apparent at first glance why the accuracy (or "limit of error" as it is more properly defined by ISA) of extension wire should be considered separate from that of the thermocouple. Actually, if extension wire of the same type and grade as the thermocouple wire is used, no *separate* error would exist. However, not only is it uneconomical to use certain types of thermocouple wire, as has been shown, but also it is impractical to hold extension wires of the same materials as the thermocouple within such close tolerance in long lengths.

From the curves of Fig. 2, note the difference in the temperature-emf characteristics between Chromel-Alumel and Copper-Constantan which is an alternate, less expensive extension wire for Chromel-Alumel couples. The error from this cause is the emf difference between the two curves at the head temperature, assuming the reference temperature is 32 F. as for the curves. The iron-alloy type of wire is used with Chromel-Alumel where greater accuracy is required.

Extension Wire Insulation. Whenever practical, extension wire should be run from the couple inside conduit and protected in every way possible from excessive heat, moisture, and mechanical damage. The variety of conditions to which it may be subjected, however, has led to the development of several different types of insulation as illustrated. In addition to its basic function of electrical insulation the wire coverings may be required to serve as physical protection under conditions of extreme weather and moisture, yet preserve their color coding.

TABLE 2. Basic data on thermocouple extension wire.

Type of thermocouple & symbol	Extension wire combination & symbol	Color code of insulation			Limits of error, °F		
		Over-all	Positive	Negative	Standard	Special	Temp. range°F
Iron-Constantan (J)	Iron-Constantan (JX)	Black	White	Red	±4	±2	0 to 400
Copper-Constantan (T)	Copper-Constantan (TX)	Blue	Blue	Red	±1.5	±0.75	−75 to +200
Chromel-Alumel (K)	Chromel-Alumel (KX)	Yellow	Yellow	Red	±6*	..	0 to 400
	Copper-Constantan (VX)	Red	Brown	Red	±6†	..	75 to 200
	Iron-Alloy (WX)	White	Green	Red	±6†	..	75 to 400
Platinum-Platinum Rhodium (R or S)	Copper-Alloy (SX)	Green	Black	Red	±12†	..	75 to 400

* ISA anticipates that this limit of error will be reduced to ±4 F when the present nickel situation improves.

† Applicable for a reference junction temperature of 75 F only.

Note: Data for this table were extracted from the ISA tentative Recommended Practices on thermocouple and extension wire.[18]

TABLE 3. Conduit capacity for various types and gages of extension wire.

Conduit size (inches)	Number of 2-Conductor Cables					
	Weatherproof and polyvinyl insulation 14 or 16 Gauge	Asbestos over asbestos insulation		Lead covered and polyvinyl insulation		Flexible rubber insulation
		14 Gauge	16 Gauge	14 Gauge	16 Gauge	16 Gauge
½	4	1	2	1	1	1
¾	7	4	4	1	1	1
1	11	6	7	1	2	3
1¼	20	11	13	4	4	4
1½	28	15	18	5	5	6
2	48	25	29	8	9	10
2½	66	36	42	12	13	15
3	101	55	65	19	21	23

Note: The above values apply to straight runs or those with nominal offsets equivalent to not more than two quarter bends. It is recommended that bends have a minimum radius of curvature at the inner edge of the bend of not less than ten times the internal diameter of the conduit.

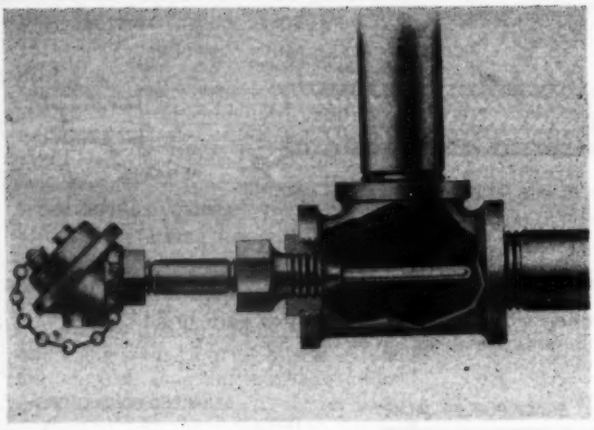

FIG. 12. Thermocouple with protecting well installed in wall of vessel. (A small diameter stainless steel well is used to increase speed of response.)

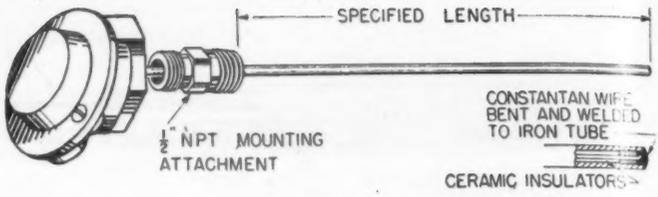

FIG. 13. "Pencil" type thermocouple with enlarged view of cross section showing construction.

Polyvinyl Plastic-Weatherproof (Fig. 8): This extension wire represents a definite advance in pyrometry. The synthetic plastic coating on the individual conductors retains its color coding. In addition this material has a high resistance to most acids and alkalies, to alcohol, gasoline, greases, and oil. The plastic coated wires are covered, as shown, with an over-all cotton braid saturated with a weatherproofing compound and finished with a color coded lacquer or paint.

This type is suitable for ambient temperature up to 140 F and has a much smaller over-all size so that many more such wires can be run in a conduit as compared to other types (see Table 3).

Asbestos-Covered Wire (Fig. 9): This wire is suitable for higher temperatures but because of the hygroscopic nature of the asbestos, the individual wires are first enamel-coated before the color-coded felted asbestos is added; this material is impregnated with a flame and moisture resisting wax and covered over-all with color-coded asbestos braid as shown. Used generally where the temperature ranges from 140 to 400 F.

Lead-Sheathed Wire (Fig. 10): A protective lead (the metal) sheath over the polyvinyl plastic extension wire of Fig. 8 makes a very rugged combination where a conduit is not employed, and at the same time affords high resistance to moisture and many corrosive atmospheres.

Rubber-Jacketed Stranded Wire (Fig. 11): Made with stranded conductors for greater flexibility, this wire is primarily employed for portable use. With its rubber-covered individual conductors and rubber jacket over-all, it is of course moisture-resistant but is not recommended for temperatures exceeding 125 F. With certain wires, synthetic rubber, such as Buna-N is available, with better resistance to attack by certain chemicals and oils.

Protecting Tubes and Wells

As has been indicated, with very few exceptions thermocouples must be equipped with suitable protection in the form of a tube or well, particularly at higher temperatures. The term *protecting tube* as compared to *well* refers to a closed end tube designed for attachment to the connection head as shown in Fig. 4; whereas a *well* is a pressure-tight receptacle with external threads for pressure-tight attachment to a vessel or in a pipe line (see Fig. 12). Literally hundreds of varieties of these tubes and wells in various metals, alloys, and refractory materials in a refinery are on the market today to meet the special requirements of the job.

A protection tube or well in a refinery is ordinarily used for one or more of these reasons:

(1) To protect the thermocouple from deleterious gases (oxidizing, reducing, contaminating, etc.).

(2) To protect a thermocouple from corrosive liquids.

(3) To provide a suitable installation for a thermocouple in a pressurized vessel (the thermocouple can be withdrawn leaving the well in place).

(4) To provide protection of the couple against mechanical damage.

(5) To support the thermocouple (particularly longer length couples installed horizontally at higher temperatures).

Desired Qualities of Tubes and Wells. Basically, the use of a protecting tube has its shortcomings from the viewpoints of ideal temperature measurement and control and installation. It obviously decreases the sensitivity of measurement, and increases the space as well as cost for a thermocouple installation. To minimize these handicaps and also to satisfy the greatest number of applications, the protecting tube or well should have as many as possible of the following qualities:

1. Resistance to high temperatures and sagging at operating temperatures.
2. Resistance to action of oxidizing and reducing gases.
3. High thermal conductivity to insure prompt transmission of temperature changes to the couple.
4. Resistance to thermal shock caused by sudden temperature changes.
5. Ability to withstand mechanical shocks.
6. Resistance to corrosion by chemicals.
7. Low porosity at operating temperature (to prevent gas leakage to couple).
8. Resistance to erosion.

In the past decade, through the cooperation of the metals and ceramic industries, considerable advances have been made in the development of special alloys and refractory materials to suit particular applications. In general, base metal couples use metallic protecting tubes and noble metal couples use ceramic protecting tubes. The latter are not discussed in further detail because of their limited use in refineries.

Types of Metallic Tubes and Selection. Various methods of constructing metal protecting tubes have been developed, each with certain advantages in application, such as;

1. *Cast, closed end*—higher temperature rigidity.
2. *Cast, open end, welded closed*—high temperature rigidity and even wall thickness.
3. *Drawn*—less porous.
4. *Drilled*—heavier wall than *drawn* and denser than *cast*.

Where erosion is a problem, even wall thickness increases tube life. If the application is in an atmosphere in a furnace, a less porous tube is desired, but if this same application necessitates a long tube at a very high temperature in a horizontal application, a cast tube might be the only answer. High pressure might dictate the use of a heavy-walled drilled tube.

Selection of the proper tube material is not such a problem in the refinery where stainless steel or carbon steel answers most of the problems. Following, however, is a check list of points to consider where some other material may be required:

1. What is the temperature involved?
2. What is the pressure involved?
3. Does the atmosphere contain sulfur? In what quantities? (If the concentration is greater than one per cent at 1000 F, nickel should not be used; this percentage becomes lower as the temperature increases.)
4. Is the installation horizontal or vertical? (Vertical installation eliminates the problem of sagging tubes at higher temperatures.)
5. Will the tube have to withstand mechanical abuse?

Response of Thermocouples

As was mentioned in the above discussion of protecting tubes, the use of an enclosure over the thermocouple is undesirable from the viewpoint of optimum measurement and control. The speed of response or rate at which the thermocouple detects temperature

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changes is of vital concern in many applications, particularly where the changes occur rapidly. Many factors of heat-transfer affect the speed of response of a thermocouple; among the most important of these are (1) the mass of the couple and (2) the air gap between the protecting tube and the couple.

The smaller the mass of the couple, the faster its response. Obviously a bare couple is best from this viewpoint, but has already been shown to be impractical. Fig. 12 shows a "small mass" design of couple using a protecting well of small diameter (approximately one-fourth that of conventional wells) and a small gage thermocouple wire.

Much the same effect is obtained in the "pencil" type couple, wherein one metal (iron or copper) of the element is in the form of an outer tube with 20-gage constantan wire inserted down its hollow center in a fashion similar to lead in a pencil. The speed of response of this type is much higher than earlier designs.

In an attempt to reduce the air gap between the protecting tube and thermocouple, methods such as illustrated in Fig. 14 have been employed. The most recent advance has been widely adopted for heavier wire gages (8, 14, and 20). The two thermocouple wires are shaped to "butt" against each other and then electrically welded. Not only has the weld been found to be very strong but also the speed of response of a protected couple of this type has been improved: (1) the mass of the hot junction is reduced, (2) the insulators are kept further away from the hot junction and minimize heat conduction away from the junction, and (3) the hot junction and adjacent portions of the wire are more nearly in contact with the inside wall of the protecting tube.

Installation of Thermocouple and Extension Wire

There are numerous practical factors to consider in making a proper thermocouple installation and connecting it by extension wire to the instrument. These will be considered under their respective headings.

Thermocouples. 1. Select the location and depth of immersion in the process vessel with care to avoid stagnant areas of the measured fluid which do not have a representative temperature.

2. Avoid direct flame impingement on protecting tube because it will materially shorten the tube life and temperature readings will not be representative.

TABLE 4. Temperature limits of common metal tubes.

Material	Maximum temp, °F	
	Oxidising atm.	Reducing amt.
Carbon steel	1000	1000
Cast iron	1300	1600
Chromel T (20% Cr, 32% Ni)	2000	2000
Inconel (14% Cr, 80% Ni)	2100	2100
Resisteat (28% Cr Iron)	1800	1800
Stainless steel (18-8)	1800	1800
Wrought iron	1200	1300

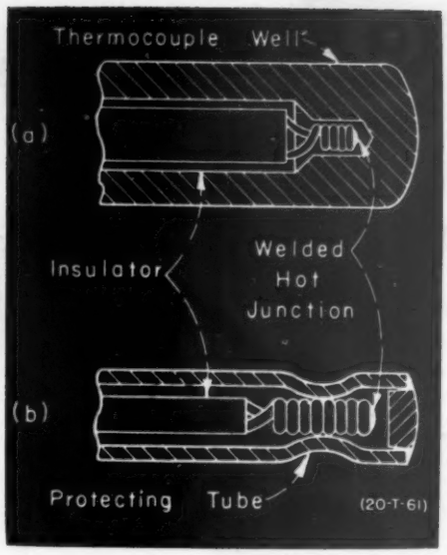

FIG. 14. Means of increasing speed of response by improving thermal conductivity between hot junction and surrounding fluid: (a) with thermocouple wells, and (b) with protecting tubes.

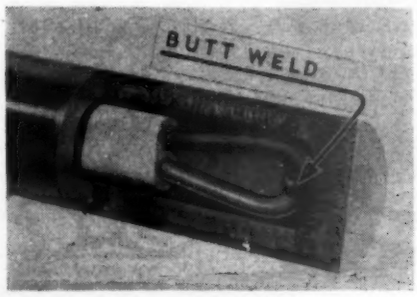

FIG. 15. Butt-welded type of thermocouple inside a protecting tube.

3. Provide for proper amount of immersion of the thermocouple into the measured medium to minimize heat transfer along the protecting tube to the connection head. Such heat conducted away from the hot junction causes the thermocouple to indicate a lower temperature (ten times the OD of the tube is the recommended minimum immersion; higher velocity fluids past couple require lesser immersions).

4. The protecting tube should extend far enough beyond the outer surface of the vessel or pipe line so that the temperature of the head approximates ambient temperature (particularly with types R, S, and K using alternate extension wires).

5. If you make your own thermocouples, clean the free ends of the thermocouple wire well before fastening them to the connection head, and be sure they are inserted with proper polarity as identified on the terminal block.

6. When measuring high temperatures, install the thermocouple vertically wherever possible to prevent sagging of the tube.

Extension Wire. 1. Use only the proper type of extension wire for a given type of thermocouple (Table 2).

2. Observe the color coding of the individual wires and connect the negative wire to negative wire terminal at both the thermocouple connection head and the instrument.

3. Avoid splicing of the wires wherever possible, and if splicing is necessary, the wires should be soldered and taped.

4. Install wires in conduit wherever possible and ground the conduit well to prevent leakage from power installations or lighting circuits.

5. Never run the wires parallel to or across any a-c line of 115 v or more within less than a foot; if this precaution isn't taken, induced a-c currents may affect the pyrometer readings. *And, of course, never run other electrical wires in the same conduit with extension wires!*

6. Select proper type of insulation to meet conditions of the installation.

General Maintenance Hints

With a thorough knowledge of the basic principles of thermoelectricity and the characteristics of common thermocouple systems, many of the factors vital to proper maintenance become self-evident. A few high spots are summarized below:

1. Thermocouples should be checked regularly at a rate determined by experience. Usually once a month is sufficient for base metal thermocouples but exceptions vary greatly from this average.

2. In re-inserting a thermocouple the depth of immersion should not be changed and, above all, should not be decreased (errors are caused by inhomogeneity in the wire due to temperature).

3. If Chromel-Alumel couples are used near the temperature limit, or in an application where the temperature fluctuates over three or four hundred degrees, they should be checked almost daily. Under these conditions, the emf of this couple has been observed to drop off slowly for a given temperature.

4. The thermocouple should be checked in place, if possible—not disturbed in any way[18a]. (Because of the limitations of this procedure many refineries have conducted surveys to determine the average life of their thermocouple in various applications and simply replaced the couples after the established proper interval; near perfect operation is thus assured and the problem of periodic checking is eliminated.)

5. A thermocouple used normally to measure a certain temperature (say 1000 F) should not be exposed to appreciably higher temperatures; because such exposure will tend to impair its accuracy.

6. Do not use thermocouples with burned out protecting tubes; replace the tubes before the thermocouple is entirely destroyed.

7. If switches are used in thermocouple circuits, be sure that their contacts are kept clean.

8. To check for grounds in the extension wire circuit, disconnect the instrument and thermocouple and use a magneto set.

9. If recording or indicating poten-

tiometers are connected in parallel for operation from a single thermocouple, the circuit should be analyzed for possible effects of one instrument on the other[10].

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* * *

Salvage of Bauxite From Acid Units[9]

W. W. MASON‡‡

Remove the Bauxite, neutralize the acid in Bauxite with water, then run through a fire drier or kiln. Then screen Bauxite to remove the fines. Bauxite is then ready to be used from four to five times.

Savings: On a 180,000 gal per day isobutane unit, 220 tons of Bauxite per year will be saved at a cost of $125 per ton, or approximately $27,000 per year. Cost of salvaging Bauxite is approximately $10 per ton, or $2200 per year. There is approximately 10 per cent loss from screening, or about $2750, which makes a net savings in one year of about $22,050. The HCl that is used to kill the iron in new Bauxite costs a few hundred dollars. The reclaimed Bauxite is free of this iron and therefore does not need to be treated with HCl acid.

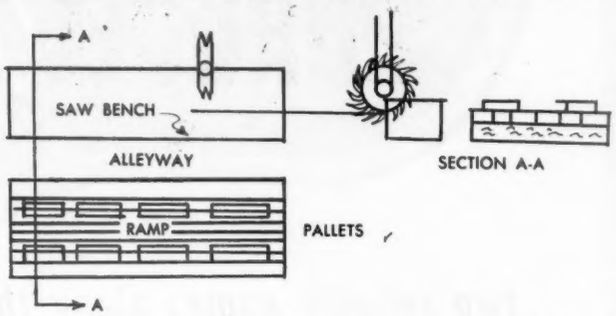
‡‡Phillips Petroleum Company, operating supervisor, Phillips, Texas.

[9]Class C, second prize, NGAA — Panhandle-Plains Regional Meeting, Amarillo, Tuesday, November 20, 1951.

Handling Sawed Lumber*

L. MINARD

Lumber cut to length was formerly brought to the saw, then stacked on the racks; then a motor lift-fork truck took off five to six feet of the stacked lumber, while that portion on the back of the rack had to be moved to the front of the rack so the lift truck could pick it up in turn.



To correct this situation, a ramp was built of 2-in. by 10-in. boards in place of the rack; it was 7 feet wide by 30 ft long. Four-inch by four-inch pallets were placed lengthwise at the outer edges of the ramp, on which the lumber was stacked; the lift truck goes up on the ramp and as finally arranged can reach any pallet at any time anywhere on the ramp. The accompanying diagram shows the principle of the arrangement.

*This plant aid submitted through courtesy of the Humble Oil and Refining Company's Coin-Your-Ideas Plan.

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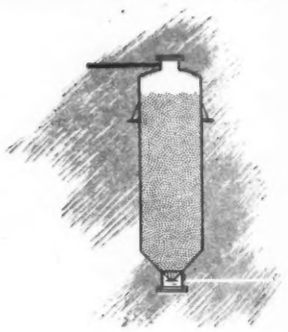

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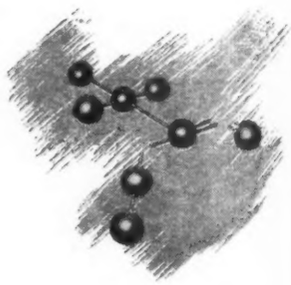

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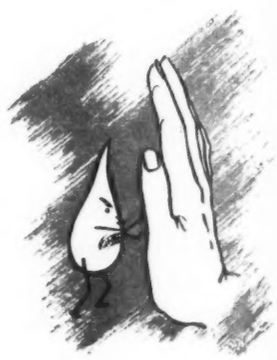

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Technical Forum

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Removal of Sulfur Compounds

Q What is a good process for removing sulfur compounds from natural gas and light refinery vapors or liquids, and what are the optimum process conditions for this purpose? Can all common types of petroleum and natural gas hydrocarbon-sulfur compounds be removed by one practical process? If not, how may the various compound types be removed, H_2S, mercaptans, sulfides, (thioethers), thiophanes and thiophenes?—*B. L. P.*

A A number of Sulfur compounds present in hydrocarbons are as follows:

Compound	*Chemical Formula*
Alkyl disulfide	R_2S_2
Alkyl sulfide	R_2S
Carbon disulfide	CS_2
Carboryl sulfide	COS
Hydrogen sulfide	H_2S
Mercaptans	RSH
Thiophane	C_4H_8S
Thiophene	C_4H_4S
Thiophenol	C_6H_5SH

R in the above signifies alkyl radicals, such as methyl, ethyl, etc. In addition, elemental sulfur is found at times in petroleum hydrocarbons, while a number of substituted thiophenes, thiophanes, thiophenols and other more complex sulfur compounds have been observed in hydrocarbons.

Hydrogen sulfide, thiophenols, and mercaptans are weak acids and will form salts with alkalies. Carboryl sulfide and carbon disulfide are essentially non-acidic, but will hydrolyze slowly to hydrogen sulfide. All the other compounds are non-acidic and will not react to any extent with alkalies.

Hydrogen sulfide and mercaptans are ordinarily the most objectionable sulfur compounds present in hydrocarbons, since they have strong odors and are actively corrosive under certain conditions.

Methods of Hydrogen Sulfide Removal

The boiling point of hydrogen sulfide, -- 79 F at atmospheric pressure, lies between those of ethane and propane, so that hydrogen sulfide may be removed quite effectively from higher boiling hydrocarbons, such as gasoline by fractionation.

In cases where fractionation is not applicable, chemical processes are ordinarily used for removing hydrogen sulfide from hydrocarbons. The principal chemical processes that have been utilized are listed below.

Chemical processes for Hydrogen Sulfide Removal:

1. Caustic Soda — $2NaOH + H_2S \longrightarrow Na_2S + 2H_2O$
2. Lime—$Ca(OH)_2 + H_2S \longrightarrow CaS + 2H_2O$
3. Iron Oxide — $2Fe_2O_3 + 6H_2S \longrightarrow 2Fe_2S_3 + 6H_2O$
   $2Fe_2S_3 + 3O_2 \longrightarrow 2Fe_2O_3 + 6S$
   (second reaction promoted by contact with air).
4. Seaboard — $Na_2CO_3 + H_2S \rightleftarrows NaHCO_3 + NaHS$ (reaction reversed by air blowing).
5. Iron-soda—(1) $H_2S + Na_2CO_3 \rightleftarrows NaHS + NaHCO_3$
   (2) $NaHS + 2Fe(OH)_3 \longrightarrow 2FeS + S + 3NaOH + 3H_2O$
   (3) $4FeS + 3O_2 + 6H_2O \longrightarrow 4Fe(OH)_3 + 4S$ ((1) reversed by air blowing (3) produced by air blowing).
6. Thylox — $Na_4AS_2S_5O_2 + H_2S \longrightarrow Na_4AS_2S_6O + H_2O$
   $Na_4AS_2S_6O + \frac{1}{2}O_2 \longrightarrow Na_4AS_2S_5O_2 + S$ (Produced by air flowing).
7. Girbotol — $2RNH_2 + H_2S \rightleftarrows RNH_3S$ (Reaction reversed by steaming).
8. Phosphate — $K_3PO_4 + H_2S \rightleftarrows KHS + K_2HPO_4$ (Reaction reversed by steaming).
9. Phenolate — $NaOC_6H_5 + H_2S \rightleftarrows KHS + K_2HPO_4$ (Reaction reversed by steaming).
10. Alkacid — $RCHNH_2COONa + H_2S \rightleftarrows RCHNH_2COOH + NaHS$ (Reaction reversed by steaming).
11. Houdry —$NiO + H_2S \longrightarrow NiS + H_2O$
    $NiS + 1\frac{1}{2}O_2 \longrightarrow NiO + SO_2$
12. Vacuum Carbonate — $Na_2CO_3 + H_2S \rightleftarrows NaHCO_3 + NaHS$ (Reaction reversed by vacuum steaming).

Caustic soda solutions and lime slurries are ordinarily not utilized on a large scale because of the cost of the reagents and the problem of disposal of the sulfide produced.

The use of iron oxide in dry boxes is one of the oldest methods for removing hydrogen sulfide from gas streams and is still used to a considerable extent. Many forms of iron oxide are used. One of the commonest consists of iron oxide impregnated wood shavings.

$$2Fe_2O_3 + 6H_2S \longrightarrow 2Fe_2S_3 + 6H_2O$$

represents the initial reaction and indicates 1 lb for iron oxide can absorb a maximum of .64 lb of hydrogen sulfide if no oxidation occurs. The addition of air causes the following reactions:

$2Fe_2S_3 + 3O_2 \longrightarrow 2Fe_2O_3 + 6S$ and $6H_2S + 3O_2 \longrightarrow 6H_2O + 6S$, so that the iron oxide is not depleted and the bed may be kept in service until the presence of elemental sulfur causes an excessive pressure drop.

For optimum performance, dry boxes require a temperature between 80 F and 100 F, a water content between 30 and 50 per cent of the iron oxide sponge weight, and the presence of an available potential alkali (as Na_2CO_3). The dry box process is completely selective for hydrogen sulfide with respect to carbon dioxide and hydrocarbons; however, partial conversion or absorption of the compounds as COS, CS_2 and HCN may occur.

This process has the disadvantages of non continuous operation and high operating cost where large quantities of hydrogen sulfide are removed from the gases being purified. However, it is well suited for the removal of traces of hydrogen sulfide from low pressure gas streams, especially where the presence of tars, air, CO_2, HCN, NH_3, COS, CS_2 and other contaminants might cause trouble in the operation of continuous processes which could produce equally sweet gas.

The Seaboard process employs a liquid absorbent that can be regenerated. The gas is contacted with a dilute solution of sodium carbonate, and the absorbed hydrogen sulfide is removed from the solution by blowing air through it. The hydrogen sulfide passes off in the air stream. The absorption efficiency of this process seldom exceed 90 per cent at low pressures although it increases with pressure. The process is partially selective for H_2S in the presence of CO_2 and absorbs HCN quite completely. It is unsatisfactory for gases containing high concentrations of HCN and other contaminants because of the occurrence of side reactions. Advantages of the process is simplicity but has a low efficiency and high power requirements.

The Iron-Soda process, a modification of the Seaboard process, represents an attempt to utilize the chemical reactions of the iron oxide dry box process in a

continuous system. Numerous modifications have been developed; however, the basic cycle consists of contacting the sour gas with a dilute solution of sodium carbonate containing suspended iron oxide (or hydroxide) and regenerating the spent solution with air.

The Thylox process utilizes a sodium thioarsenate solution for removing hydrogen sulfide from gases. On blowing air through the solution, after it has absorbed hydrogen sulfide, the thioarsenate solution is regenerated and elemental sulfur (recoverable as a marketable by-product) is produced.

If no credit is taken for recovered sulfur the operating cost of this process is relatively high, and its complexity constitutes an additional disadvantage over other processes.

The Girbotol process employs solutions of amines for separating hydrogen sulfide from hydrocarbons. This process has become the one most widely used for this purpose. The removal of hydrogen sulfide from hydrocarbon gases or liquids by this process is carried out by contacting the gases or liquids with solutions of amines (organic alkalies). The absorbed hydrogen sulfide is then separated from the amine solution by heating, which regenerates the amine solution for further hydrogen sulfide absorption. This regeneration takes place because the amine sulfides dis-associate readily at slightly elevated temperatures and release the hydrogen sulfide that has been absorbed at lower temperature. The wide spread use of this process has resulted from two factors. First, it is the only commercial process using liquid absorbents that has been utilized for purifying gases to the degree commonly required for pipe-line distribution. Second, the operating costs of the process have been lower than other processes primarily due to smaller steam requirements for regeneration. The hydrogen sulfide removed from the hydrocarbons is recovered in a concentrated form, and may be utilized for the production of elemental sulfur, sulfuric acid, or other purposes.

The Phosphate process employs a solution of tri-potassium phosphate for removing hydrogen sulfide from hydrocarbon gases or liquids. This is regenerated by steaming in a manner similar to that employed in the Girbotol process.

For ordinary gas treating operations, the process is not competitive with amine processes. This process does have certain features which make it useful. The high stability and non-volatile nature of the tri-potassium phosphate make it applicable for absorption temperatures as high as 200 F and for gas streams containing reactive contaminants. Its insolubility in hydrocarbons make it useful in treating liquid hydrocarbons.

The Phenolate process utilizes a solution of sodium phenolate for removing hydrogen sulfide from gases. Steaming is used for regeneration.

The capacity of the phenolate solution for hydrogen sulfide is quite high, the efficiency of hydrogen sulfide removal is generally low (90 per cent) and the steam consumption is high.

The Alkacid process uses solution of sodium slats of amine acids for hydrogen sulfide removal. This process was developed in Germany and has not been used commercially in the United States.

The Houdry process for removing hydrogen sulfide from hydrocarbons uses nickel oxide on a refractory support at a temperature of 700 to 800 F. The nickel sulfide is reconverted to nickel oxide by air blowing at the same temperature. The operation is intermittent with multiple chambers being used.

The vacuum carbonate process is a modfication of the Seaboard process, using vacuum steaming for regenerating sodium carbonate solution that has absorbed hydrogen sulfide. It has the advantage over the Seaboard process in that the hydrogen sulfide may be recovered in a concentrated form.

In addition to the above discussed processes for hydrogen sulfide removal, a number of other processes have been employed, such as use of activated charcoal, silica gel, alkaline solutions containing copper chloride, hypochlorite and others, but none are in general use.

Methods for Mercaptan Removal

Since mercaptans of the different homologues have widely varying boiling points they are found in practically all hydrocarbons. Methyl and ethyl mercaptans are found in natural and refinery gases, while these and higher molecular weight mercaptans occur in gasoline and other distillates. The processes for the removal of mercaptans from gasoline have been summarized and fall into three types, (1) those which chemically convert mercaptans to disulfides; (2) those which remove mercaptans but do not effect other sulfur compounds, and (3) those which remove some or all of the different types of sulfur compounds.

Processes of type 1 do not decrease the total sulfur content of the gasoline but oxidize the mercaptans to disulfides which have a less objectionable odor. These processes include doctor-treating, lead sulfide processes and copper chloride.

Processes of type 2 are regenerative and remove the mercaptans from the gasoline. They are operated in a manner similar to the liquid absorbent processes used for hydrogen sulfide removal. These processes include: (1) The regenerative caustic process using caustic soda solutions which react with mercaptans to form sodium mercaptides. These are separated from the solution by steam stripping. This process is effective for removing low molecular-weight mercaptans from gasoline and other hydrocarbons, but does not give good results with high molecular weight mercaptans. (2) The Shell Solutizer process using a caustic solution containing solubility promoters such as sodium or potassium iso butyrate or alkylphenols. These increase the solubility of the high molecular-weight mercaptans in the gasoline and make possible complete mercaptan removal. Regeneration is by steam stripping. (3) The Pure Oil Mercapsol process using mixtures of naphthenic acids and other organic compounds such as alkylphenols for solubility promoters in caustic solutions. Steam stripping is used for regeneration, with provisions for complete methanol recover. (5) The Socony-Vacuum Tannin Solutizer process using a caustic-soda solution containing solubility promoters similar to those used in the Shell Solutizer process. Regeneration is effected by air blowing at 130 F in the presence of about 1 per cent tannin, catilizing oxidation of mercaptides) to disulfides. The disulfides are insoluble in the caustic solution generation by air blowing in this process and separate from oil. The cost of regeneration by air blowing in this process is less than the regeneration by steam in the other processes.

The type 3 mercaptan-removal processes include: (1) Sulfuric acid treating, the acid oxidizes mercaptans to disulfides, which are somewhat soluble in the acid, and are partly removed. Partial removal of other sulfur compounds is also obtained. (2) Catalytic desulfurization processes, in which hydrocarbons are passed over catalysts at elevated temperatures. Mercaptans and other sulfur compounds are converted to hydrogen sulfide, which may be removed from the hydrocarbon by any suitable process. The catalyst gradually becomes inactive and may be regenerated by air blowing to burn off accumulated carbon and sulfide, although in some cases it is cheaper to replace the spent catalyst. (3) Catalytic-hydrogenation processes, in which hydrogen is added to the hydrocarbons to aid in the conversion of organic sulfur compounds to hydrogen sulfide when passed over catalyst in a manner similar to that used in catalytic desulfurization processes. In general, catalytic-hydrogenation processes for sulfur removal supplement the straight catalytic desulfurization processes, and are used in cases where the sulfur content is so high that satisfactory results are not obtained with straight catalytic desulfurizations.

The successful operation of processes of type 1 and 2 requires prior removal of hydrogen sulfide from the hydrocarbon because the reagents used will react to form sulfides that cannot be readily regenerated. With processes of type 3, hydrogen sulfide removal is not essential.

Removal of Other Sulfur Compounds

Carboryl sulfide, COS, probably does not occur naturally in petroleum hydrocarbons, but may be produced in cracking operations, and occurs at times in refinery gases. Its boiling point — 54 F at atmosphere pressure is very close to that of propane (—48 F) and carboryl sulfide is often found in propane obtained from refinery gases. Carboryl sulfide may be removed from hydrocarbons by alcoholic caustic solutions, by primary amines, or by catalytic desulfurization or hydrogenation processes, which convert it to hydrogen sulfide.

Carbon disulfide may be removed by

the processes utilized for carboryl sulfide removal.

Thiophenols (arylmercaptans) are acidic in nature and may be removed from hydrocarbons by alkaline reagents.

Most of the other sulfide compounds occuring in petroleum hydrocarbon may be removed in part, at least, by catalytic desulfurization and hydrogenation processes.

At the present time research and engineering development work is being actively pursued toward the development of a practical process to remove all kinds of sulfur. In addition to the Rectisol process which is presently being developed in this country, a broad and extensive research program is being conducted by the Institute of Gas Technology on organic sulfur. The Gas Institute's broad program includes a study for the removal of specific organic sulfur compounds in utility gases utilizing chemical reactions and thermal or catalytic conversion; and a study of the operating variables encountered in the removal, by absorption or adsorption, of organic sulfur compounds present in coal, carbureted water, oil or natural gases.

Frank H. Dotterweich.

Treatment of Alkylates

Q What treating is given to alkylates from either process, following the initial alkylation reaction? Are there differences in these treatments for the two products?—B. L. N.

A In the case of sulfuric acid alkylate the mixture of hydrocarbons separated from the acid catalyst is caustic washed before fractionation. In most cases this is the only treatment given, although the aviation alkylate cut from the fractionator may in some cases be given a light caustic wash. Traces of sulfur compounds are carried over into the alkylate as by-products of the alkylation reaction, but the cost of removing them is usually in excess of the benefit derived by their removal.

In hydrofluoric acid alkylation the total hydrocarbon stream separated from the acid catalyst is passed through bauxite in the liquid phase at about 180-185 F. Most of the fluorine is here converted to AlF_3, but some SiF_4 is produced from the silica in the bauxite. If this silicon tetrafluoride is not removed it will hydrolyze and plug the fractionating tower accumulators where water separates out as a separate phase. If care is taken the trouble can be avoided by scrubbing the hydrocarbon stream leaving the bauxite treaters with dilute caustic soda. The aviation alkylate cut may then be given a final scrubbing with dilute caustic. Because of the insolubility of sodium fluoride it is necessary to use dilute caustic.

A complete description of the hydrofluoric acid alkylation process is found in a book published by Phillips Petroleum Company in 1946 under the title "Hydrofluoric Acid Alkylation."

C. R. Wagner.

Ethylene Oxide Processes

Q What is the most commonly used process for the production of Ethylene Oxide? Outline the main steps in the process, catalysts, with typical yields and byproducts if any of importance are produced? What are the main economic factors in operating the process, as of present industrial conditions?—M. C. V.

A Two processes are in current use on a large scale; 1. the older is the so-called chlorhydrin process[1]; 2. the newer process is the catalytic[2] oxidation process.

The first commercial process installed in the United States was built at South Charleston by Carbide and Carbon about 30 years ago. Ethylene, purified by low temperature fractionation, was reacted with hypochlorous acid to produce ethylene chlorhydrin, with some ethylene dichloride as a by-product. Careful hydrolysis of the chlorhydrin yields ethylene glycol as the principal product, but treatment with a slurry of hydrated lime yields ethylene oxide as the chief product. The reactions are:

$$(1)\ C_2H_4 + Cl_2 + H_2O \longrightarrow C_2H_4ClOH + HCl$$

$$(2)\ 2\,C_2H_4ClOH + Ca(OH)_2 \longrightarrow 2\,C_2H_4O + 2\,H_2O + CaCl_2$$

The ethylene oxide is purified by fractionation. One of the impurities hardest to remove is acetaldehyde, which is produced by rearrangement of the ethylene oxide molecule.

In the catalytic oxidation process ethylene mixed with air (and possibly inert gas and steam) is passed over a metallic silver catalyst. The temperature employed is usually in the range of 250 to 300 C. The oxidation to CO_2 and H_2O is quite exothermic and control of the temperature is necessary to avoid low yields of oxide. The form of the catalyst appears to be critical, and the presence of a certain amount of water vapor is also essential.

The patent to Lefort (U. S. 1,998,878), purchased by Carbide and reissued in 1937, was the basis of litigation over a period of years, because it covered this process rather broadly. Although upheld by the District Court and Circuit Court of Appeals it was held invalid by the Supreme Court in 1942. Since that time a number of firms have offered to build catalytic oxidation process units. Some of the more recent plants built, however, have been based on the older chlorhydrin process.

Ethylene oxide readily polymerizes to produce a waxy material, and when heated under pressure will detonate violently. Some people prefer to store the material in refrigerated tanks, but this appears unnecessary if the oxide is not to be held in storage over a long period of time.

The yield by the catalytic route is usually in the range of 50 to 60 per cent conversion to the oxide. By the chlorhydrin route the yield is much higher, but the cost is correspondingly higher because of the use of chlorine. As can be observed from the equations above, about 71 lb of chlorine are required to produce 44 lb of oxide, if you assume 100 per cent efficiency. Of course such yields are not attained.

The catalytic process requires a higher purity ethylene, but practically no other raw material is used, and the by-products are not of serious consequence. The chlorhydrin process depends upon a supply of chlorine, and this may be affected by the market for caustic or for sodium. In addition it is necessary to dispose of sizable quantities of by-product ethylene dichloride.

C. R. Wagner.

[1]Ellis, Chemistry of Petroleum Derivatives, Vol. II (1937), pp. 550-1 also B. T. Brooks in Chem. & Met. Eng. *22*, 629-633 (April 7, 1920).
[2]A good literature survey is found in an article by McBee in Ind. Eng. Chem. *37*, 432-438 (1945).

Fuel Demands Are Being Met by Use of Oil Components

Chemical engineers are now producing more gasoline at a lower cost than ever before from crude oil components, formerly unused, and are meeting the need of our ever-increasing demand for engine fuels, according to Dr. R. C. Gunness, assistant general manager of manufacturing of the Standard Oil Company (Indiana) in a talk at the Chicago, Illinois, meeting of the American Institute of Chemical Engineers. This more efficient utilization of our country's petroleum resources is rapidly being accomplished by a new fluidized-solids technique, said Gunness.

Refining of crude oil involves the separation of its various components; one of the more important of these is gasoline. Gunness revealed that more of this product may be obtained by conversion of less desirable crude oil fractions such as gases and heavy oils.

The principle of fluidization is that of taking a finely divided solid and blowing a gas through it at a high enough velocity to make the bed of solids assume liquid properties. This is similar to the addition of heat to a liquid where it eventually boils and becomes a vapor. In the petroleum industry, said Gunness, the raw materials are vaporized and blown through the fluidized catalyst where the chemical reaction takes place. Again in regeneration of the catalyst, the fluidizing properties are utilized when air is blown through the catalyst to burn off coke formed during the chemical reaction.

Huge quantities are being handled by the commercial fluid catalyst units. As an example, Gunness mentioned one which has a capacity of 25,000 bbl per day containing 500 tons of catalyst, which circulates at a rate of 20 tons per minute. In 11 years expansion has occurred so that total design capacity is now 1,400,000 bbl per day, two-thirds of which has been put in operation since the war. According to Gunness application of this process has been made in other industries such as producing chemicals, coke, and calcined limestone.

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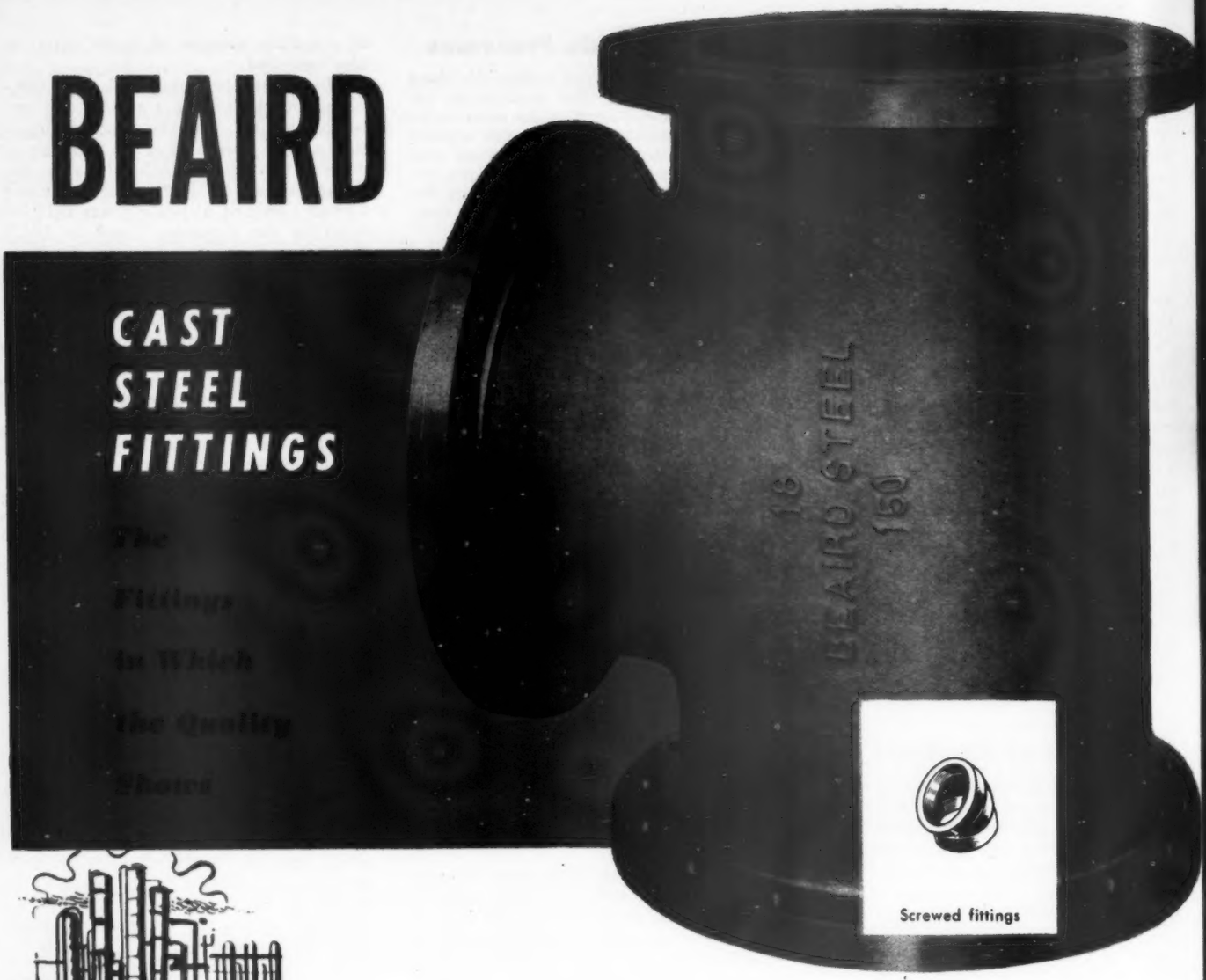

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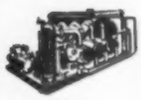
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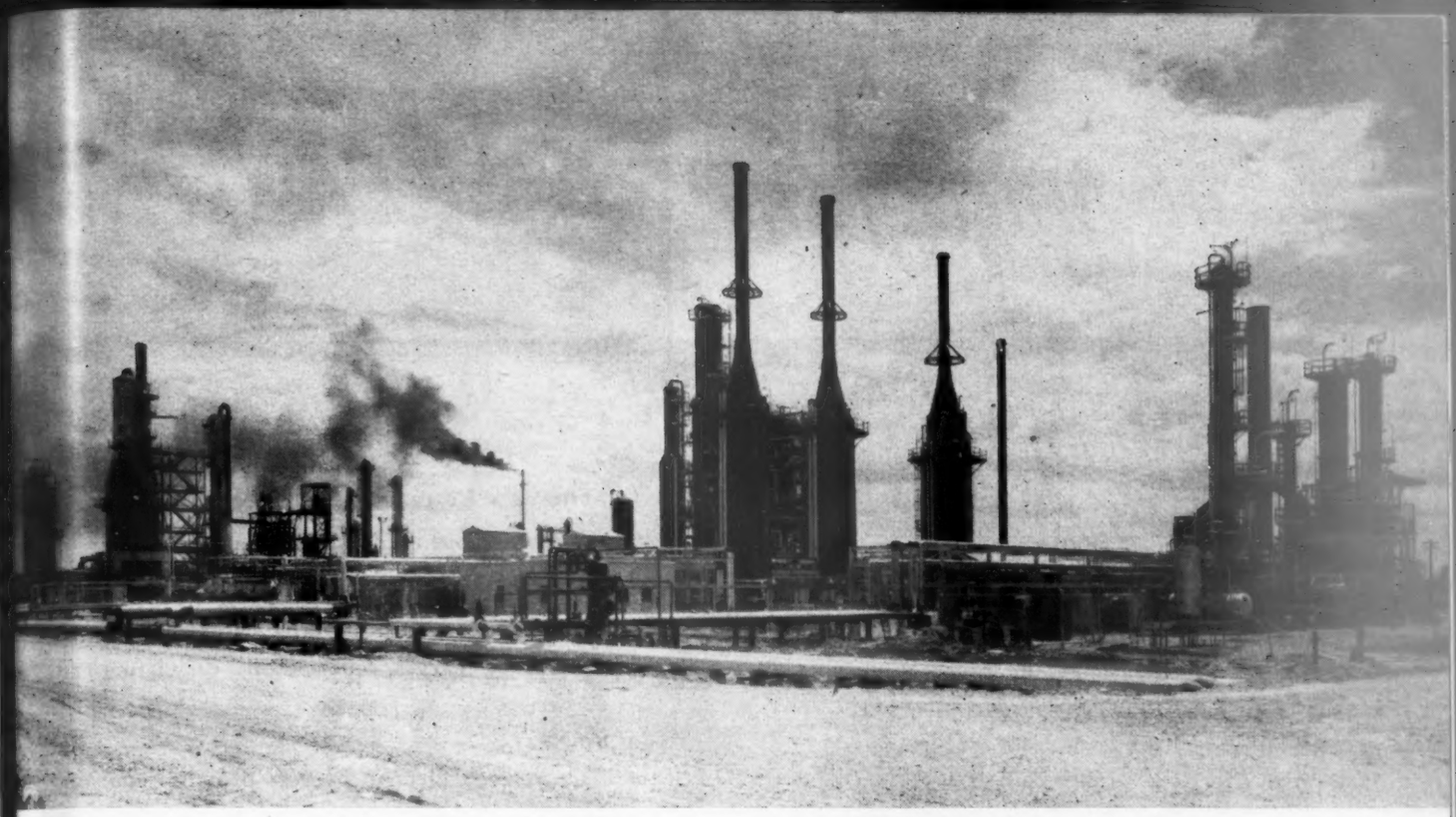


Looking southeast toward catalytic cracking, crude distillation, and catalytic reforming units.

P 710.1

Canada's First

Orthoflow and Platformer Units on Stream

New $23,000,000 refinery at Sarnia is pouring oil products into Canada's petroleum-hungry economic system

E. A. SMITH* and F. J. MASLYK†

CANADIAN OIL COMPANIES, LTD., is celebrating its fiftieth birthday as a refiner this year. It embarked on its second half-century with the official opening, September 25, of a $23,000,000 refinery at Sarnia, Ontario. The new plant has been in full operation for some time, following a unit by unit start-up beginning last spring.

Sixteen miles due west from Petrolia, Ontario, where Canadian Oil Companies first began refining operations 50 years ago and just south of Sarnia, Ontario, on the St. Clair River, a new modern plant embodying techniques right off the drawing board has begun to pour the first of millions of gallons of motor and aviation gasolines, jet and other fuel oils, and synthetic rubber, and chemical ingredients into Canada's expanding petroleum-hungry economy.

The Sarnia project is part of Canadian Oil's $27,000,000 program of expansion on half of a 400-acre site that less than two years ago was undeveloped farm land. The new refinery, bordering on the St. Clair River, was built without frills, but sufficient flexibility was provided to permit special products to be made with minimum additional equipment. Large areas were provided for future expansion of the refinery proper and for the addition of petrochemical industries or other allied industries along side.

Canadian Oil Companies, Ltd., as a result of recommendations and studies by Stone and Webster Canada Ltd., authorized them to proceed with the management of design and construction of the new refinery just outside the city limits of Sarnia. At that time negotiations were well advanced for an adequate supply of crude oil from Alberta. A little later Canadian Oil contracted for a 5,000,000-bbl per year supply of Alberta oil for 10 years. It flows to the lakehead via the Inter-Provincial Pipe Line, in which Canadian Oil has a substantial investment. Thence the crude oil is transported via Great Lakes tanker from Superior, Wisconsin, to the new refinery's wharf at Sarnia.

Stone and Webster Engineering Corporation handled the design and construction of practically all the general services. They also co-ordinated all design and construction activities of the many sub-contractors. The administration of all contracts was handled by the project managers.

The firm of Proctor, Redfern, and Laughlin of Toronto, Ontario, designed the water supply systems, which include:

1. Water treating.
2. Waste disposal facilities.
3. Part of plant protection devices.

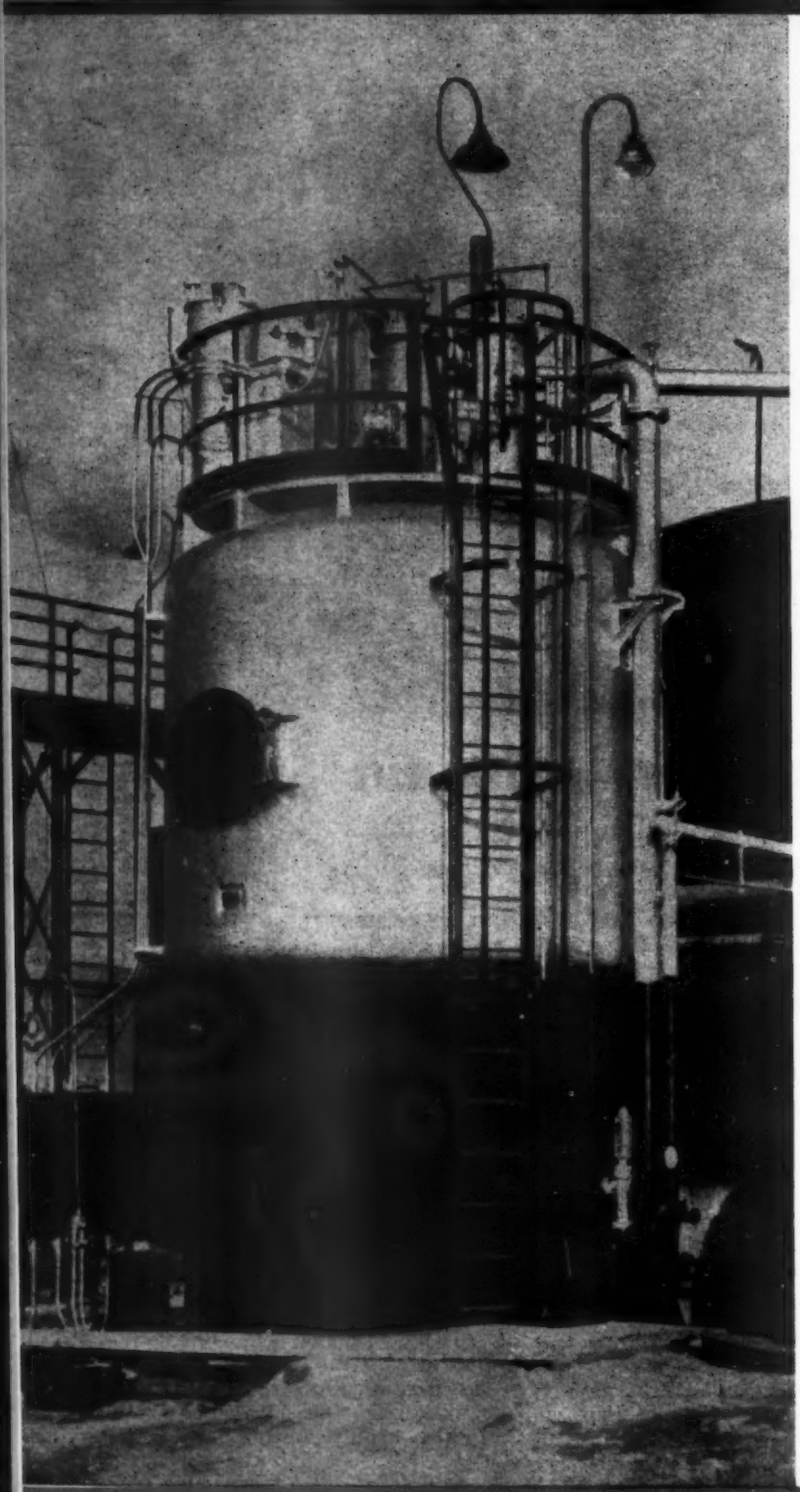
The three main process unit groups consist of:

1. Crude distillation unit designed by Badger process division of Stone and Webster Engineering Corporation, and

*Manager of Manufacturing, Canadian Oil Company, Ltd.

†Project Engineer, Stone and Webster Engineering Corporation.

Announcing the NEW



The new Petreco Electric Process takes the guesswork out of distillate treating. It is applicable to acid, alkali or doctor treating of distillate stocks such as naphtha, gasoline, kerosine, cat-cracker charges, cat-cycle oils, diesel fuel and furnace oil.

The Petreco Electric Process provides continuous, automatically controlled treating *with predictable results.* It utilizes less equipment, occupies minimum ground space, requires fewer pumps, less operating attention and eliminates the need for mechanical separating devices. Processing is in a closed system; no fumes or air pollutants can escape. Except for the few pumps required, there are no moving parts. Because the treating operation is automatically controlled with precision devices, the treating agent (acid, caustic, doctor) requirements are generally less per barrel of oil treated than those of conventional systems. As indicated in the flow diagram, treating for a one-phase system is carried on in a comparatively small, self-contained vessel. Multiple stage systems of any given capacity can be designed to suit refinery requirements.

In refinery use the Petreco Electric Distillate Treating Process has shown substantial savings in treating agent usage alone. In addition, considerable savings are to be gained in power usage as well as in operating and maintenance time.

PETRECO

ELECTRIC PROCESSES FOR THE PURIFICATION OF PETROLEUM

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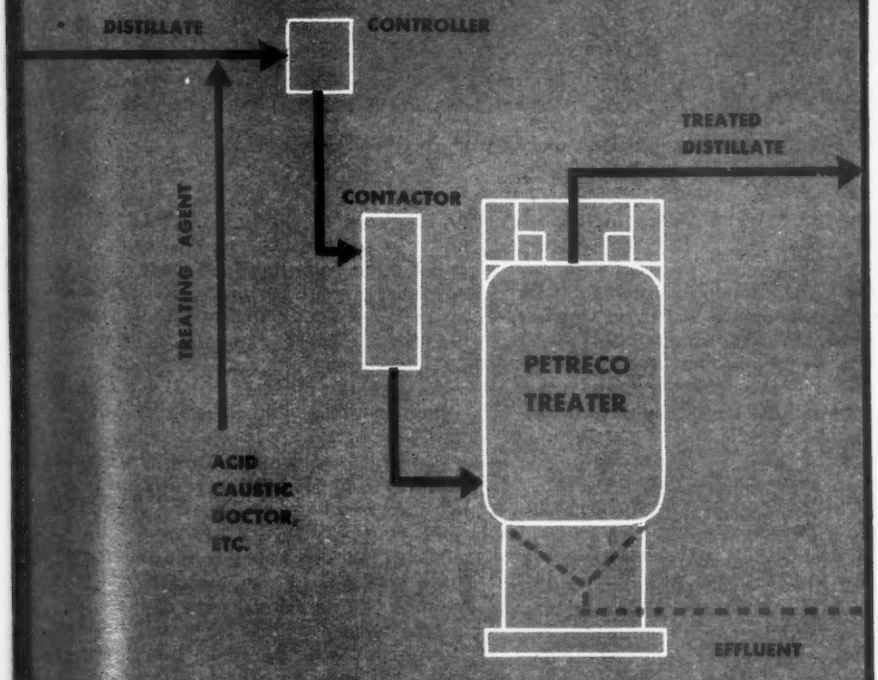
ELECTRIC PROCESS

for

DISTILLATE TREATING



Flow diagram of typical, single-stage Petreco Electric Distillate Treating Process

Advantages

COMPACT — requires minimum space, minimum equipment.

ECONOMICAL — uses less treating agent, gives higher product yield.

AUTOMATIC — injection, contacting and separation are automatically precision-controlled.

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constructed by Stone and Webster Canada Ltd.

2. The catalytic cracking, gas concentration, and catalytic polymerization units were constructed by the Canadian Kellogg Company Ltd., from designs supplied by the M. W. Kellogg Company of New York.

3. The catalytic platforming unit was designed by the Universal Oil Products Company and constructed by its subsidiary Procon Inc. This is the first platformer in Canada.

Unique features of the refinery consist of its proximity to the federally-owned Polymer Corporation, the only synthetic rubber plant in the British Commonwealth of Nations, and to Dow Chemical of Canada Ltd., which has rapidly expanded into one of the major chemical industries in Canada; and of the collection, processing, distribution, and utilization of many gases resulting from refining. Very little gas is burned in the refinery with the exception of hydrogen sulfide, and it is expected that in the not too distant future even this gas will be sold or utilized for the production of sulfur and/or sulfuric acid.

Methane, ethane, and ethylene from the de-ethanizer go in gaseous stream to Dow, which extracts the ethylene and ethane from the stream, crack the ethane to ethylene, united with the ethylene extracted from the refinery stream. The methane is utilized as fuel gas.

A liquid stream of propane from the catalytic polymerization unit also goes to Dow which cracks it to ethylene. Propylene, incident to the pyrolysis of ethane and propane, is returned to the refinery, to be polymerized along with the propylene incident to the refining operations, separated from the overall gas stream at the C_3-C_4 splitter.

The poly plant operates almost entirely on the propylene from the refinery and that returned from Dow. Production of poly gasoline is thereby maintained, even though the full C_4 stream is sent to the Polymer Corporation, which separates the isobutylene for the production of butyl rubber and the normal butenes for the production of GRS-type rubber.

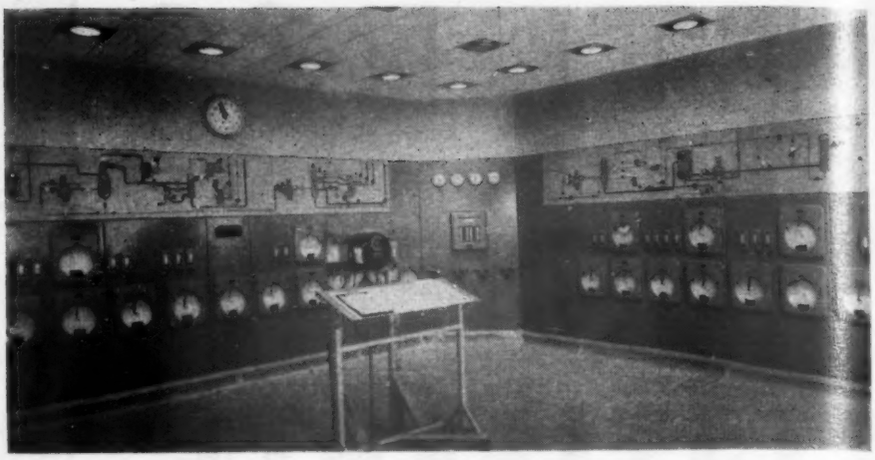
The normal butanes are returned to the refinery for the control of vapor pressure and front end volatility of the several gasolines produced.

Crude Distillation Unit

There are five separate operations at the crude distillation unit:

1. Chemical de-salting.
2. Crude pre-flashing.
3. Atmospheric distillation.
4. Vacuum distillation:
5. Vis-breaking.

The light naphtha from the pre-flashing, stove and diesel oil products from atmospheric distillation are individually treated for removal of undesirable materials and are sent to storage tanks. Heavy naphtha from the atmospheric column goes to the platformer, for upgrading to high quality motor and aviation gasoline products. Some light gas oil, and all of the heavy gas oil from the atmospheric and vacuum columns go to the Kellogg Orthoflow catalytic cracking unit, for conversion to a high quality motor gasoline.



Control room for distillation unit at Canadian Oil Refineries plant.

Control room for catalytic cracking and gas recovery units.

Heavy vis-broken residual not required by the refinery is blended with cycle-stock from the catalytic cracker and, within the crude unit, into bunker fuel oil product and delivered to storage tanks to subsequently be shipped via marine tanker, motor transport and railway tankcars.

The Platformer

Much has appeared in literature dealing with the theory and application of platforming and catalytic reforming. In the platformer, because of its multi-stage, self-regenerating reactor system, several reactions can be induced and completed with comparative ease. Naphthene or cyclic hydrocarbons are dehydrogenated to aromatic or ring-type hydrocarbons. Normal or straight-chain paraffin hydrocarbons are isomerized or branched-chain or iso-compounds. Hydrocracking also occurs so that altogether the components of the finished platformate are very desirable in both motor and aviation gasolines. The platformer at Canadian Oil, has three reactors. There are a few innovations that are interesting. In view of the close fractionation accomplished at the crude unit, it is unnecessary to use a pre-fractionator ahead of the platformer. In order to remove last traces of moisture and oxygen from the platformer charge, however, a small stripper was installed through which hydrogen is bubbled through the charge, removing those objectionable ingredients.

A Girbotol unit strips all hydrogen sulfide from the effluent gas stream as well as from the hydrogen recycle.

A re-run column has been provided, so that the platformate can be split into two streams, light and heavy; the light complying with distillation requirements of aviation gasoline and the heavy forming a most desirable ingredient for motor gasoline. The design capacity of the platformer is 3800 bbl daily, but the unit has already operated with ease well over 4000 bbl.

In fairness to the designers and construction people, it should be mentioned that this unit went on stream immediately and more than met the guarantees and has scarcely been touched since. It has operated perfectly since the first day of operation. Indications are that catalyst life will far exceed that guaranteed.

In the event that it is imperative maximum jet fuels be produced, most of, or all, the heavy straight run naphtha would be required for that purpose. In that event the light straight run from

the crude unit pre-fractionator can be charged to the platformer, making up the deficiency of normal charge stock, and still produce a maximum of aviation blending stock very rich in aromatics. This, inasmuch as the light straight run contains a mixture of normal and isopentane, cyclopentane, methlycyclopentane, cyclohexane, methylcyclohexane, C_7's and higher hydrocarbons from which more isopentane, Benzol, toluol, and zylenes can be produced.

The effluent hydrogen stream from the platformer contains well over 85 mol per cent of hydrogen. A hydrogen storage drum is being installed to provide adequate storage for start-up hydrogen or to supply to other chemicals or process industries. It, of course, would be available should it be found necessary at a later date to go the hydrogenolysis route. It is already indicative that in the not too distant future this hydrogen will be required. Excess hydrogen is produced at the rate of 750 to 900 net cubic feet per barrel of charge, depending on the severity of cracking and the conditions of operation.

Cat Cracker Unit

Three gas oil intermediate products from the crude unit are delivered directly to the cracking unit without being cooled. Those products are converted catalytically into gasoline, domestic burner fuel, and blending stock for bunker fuel. Variations in the gas oil production rate at the crude unit are balanced by diverting a portion through a cooler to a large storage tank. This also makes provision for a suitable inventory of catalytic cracking stock in the event the crude unit is shut down for repairs or turn-around.

The cracking unit is the Kellogg Fluid Orthoflow type, in which the converter consists of both reactor and regenerator in a single vessel. The unit is a first in Ontario and is the third of such design by Kellogg. Many new ideas were incorporated in the construction of this unit, making it a "last word" of its type. It represents a significant simplification of earlier designs by the elimination of all large external piping, expansion joints, and valves. Both the spent and regenerated catalyst lines are straight lines contained within the converter vessel itself. The design of the unit has been arranged to permit operations over a wide range of conditions as may be necessitated by stock availability, or product sales requirements.

Although the catalytic cracker normally produces a cracked gasoline, a light cycle stock suitable for No. 2 fuel oil and a blending oil which is used to dilute residual fuel, heavy decant oil may also be produced as a by-product. As in the Platformer, provision has also been made to split the catalytic cracked gasoline stream into two parts, light and heavy, the light forming another source of aviation gasoline supply, should future conditions warrant.

Compression of the gases produced in the cracking unit is effected by means of a turbine-driven centrifugal equipment and delivers the gases to an absorber stripper system designed for high C_3 retention. In this system the gaseous ingredients for manufacture of synthetic chemicals and synthetic rubber are retained to be later removed, separated and purified, then delivered by pipe line to Dow Chemical of Canada Ltd., and the Polymer Corporation. The unit in conjunction with the gas recovery and catalytic polymerization units yields a propane product conforming to conventional LPG propane specifications, and any excess not required by Dow is being sold as LPG product. A Girbotol unit is also incorporated in this group in order to insure that all gaseous products are scrubbed free of hydrogen sulfide and carbon dioxide.

Process Control

Nothing has been spared in the way of instrumentation and the control instruments are housed in two main control rooms, the one room taking care of the catalytic cracker gas concentration, catalytic poly and Girbotol units, the other room the crude distillation unit, the platformer, and a Girbotol unit. After careful consideration semi-graphic panels were selected and placed in a setting of warm colors and soft lighting to permit instantaneous detection and correction of even the slightest irregularities in operation. Permanent-colored line charts are installed over the instruments to assist the operators in visualizing the entire processes and the exact condition at any given instant.

General Facilities

Crude oil is unloaded from and products loaded into Great Lakes tankers at the new steel and concrete ship-wharves, the first of their kind in the Sarnia area. These docks are so arranged and the piping so designed that they can be used inter-changeably, and they are separated sufficiently to permit the operation of both without interruption. Crude oil can be unloaded at the rate of 15,000 bbl per hour and products can be loaded at the rate of 5000 bbl per hour.

Each wharf has facilities for bunkering ships with diesel and bunker fuel oil. Drinking water, compressed air, and steam are also available. Two ramps or run-ways are provided so that ships can be provisioned by delivery trucks at ship's side. Spillage of oil at the platforms is contained in built-in sumps on each wharf and is pumped together with bilge from ships to oil recovery equipment. Suitable lighting, racks, derricks, etc., are provided to facilitate handling of hoses and other materials incident to Great Lakes' traffic.

The products made in the process unit groups that are delivered to the storage tanks are transferred or blended into separate tanks by a group of pumps contained in the transfer pump-house. Shipment can be made by boats, tank cars, or tank trucks.

Gasolines are especially processed and segregated to prevent storage and handling losses. They are blended to the desired grade immediately before shipment. The blending operation includes the combining of:

1. Catalytic cracked gasoline.
2. Platformate.
3. Light straight-run naphtha.
4. Butanes.
5. Oxidation inhibitors.
6. Anti-knock fluid, if necessary.
7. Required dye colors.

The entire blending operation is performed automatically, by means of a special robot designed for this purpose and supplied by proportioneers. If desired, blending may also be performed without the automatic devices.

Gasoline may be blended directly into tankers for shipment, or to separate storage tanks, for delivery by tank car or tank trucks, at a rate of 5000 bbl per hour. With the exception of vis-broken residual, all products are treated continuously as they leave the process units. In other words, they are treated on their way to run-down and storage.

Stove oil, diesel oil, No. 2 fuel oil, and bunker fuel oil products are normally gaged and retested in their tanks and pumped directly to boats or to separate tanks for shipment by tank car or tank trucks at the same rate as gasoline.

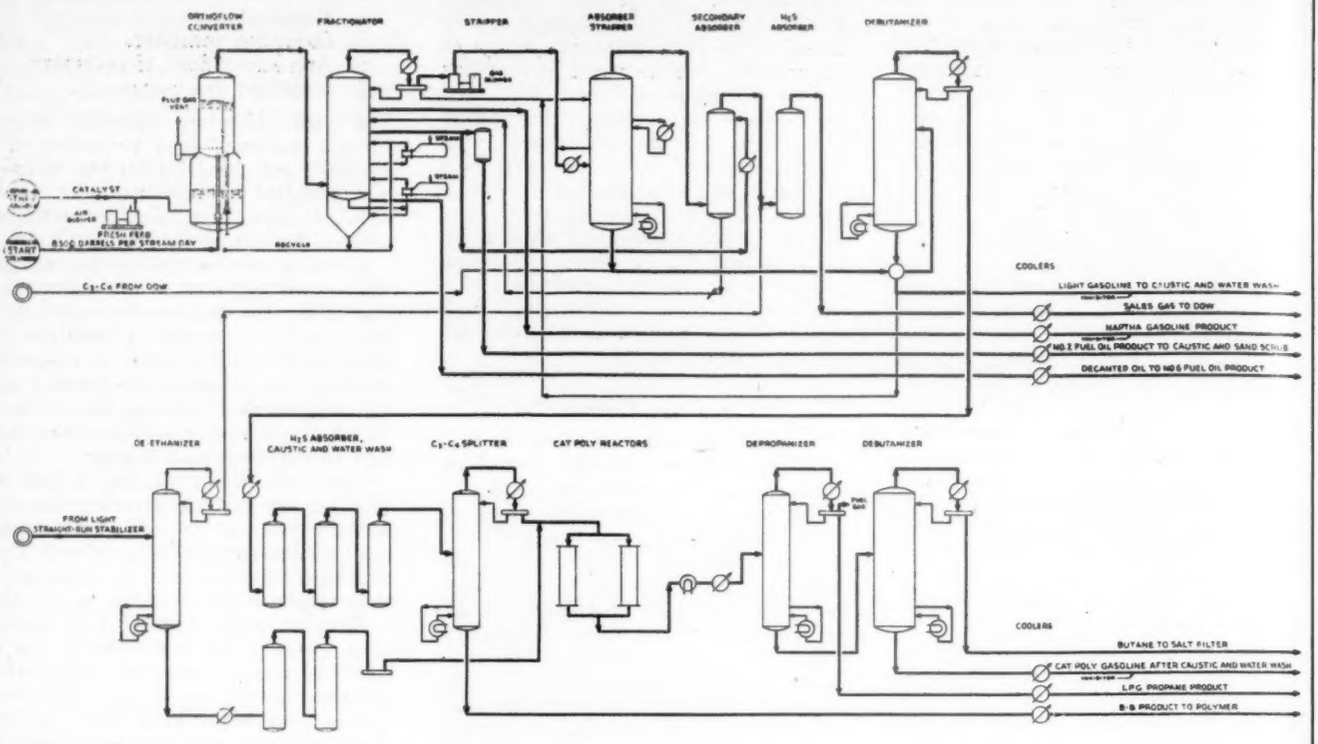
More than 2,000,000 bbl of storage tank capacity are available on the refinery premises. Cone-roof, floating-roof, spheres, hemispheroid, and bullet-type pressure varieties have been utilized. The tanks were designed and erected by Horton Steel, of Fort Erie, Ontario, and the Toronto Iron Works of Toronto, Ontario. A large proportion of the steel plates going into their construction was supplied by Steel Company of Canada.

Each tank was carefully designed for its intended services, and provided with the latest protective devices. Freeze-proof water drainage connections are provided including a drainage piping system for cleaning or emergency evacuation into special handling equipment for recovery of all traces of oil before discharging the water. Adequate dikes are provided to contain any spillage. The dikes can be drained and the oil recovered.

Six large tank trucks may be loaded simultaneously from three loading spots under a steel-supported canopy with space provided for additional stations. Products can be delivered from the storage tanks to trucks at the rate of 500 imperial gallons per minute, per truck, by means of swivel loading arms. Air eliminators and ticket printing meters are provided on all products except bunker fuel oil. The dock was originally designed to accommodate 4000 imperial gallon trucks, but was modified in the later phases of construction to accommodate 5200 imperial gallon trucks for gasoline. A gate-house controls the flow of traffic and is provided with emergency controls for the pumping equipment.

A grated steel structure provides space for 26 tank cars that may be filled with products from the refinery, including propane and butane. Products are delivered from separate tanks, by means of pumps, directly to the cars through swivel loading arms.

Each loading station has facilities for cleaning and draining the tank cars through a system of pipe lines leading to the oil recovery equipment. The loading



Catalytic cracking, gas recovery, and catalytic polymerization units at Sarnia refinery.

rack has been designed for future expansion as required.

A separate canopy covers three sets of dual meters on all products shipped by pipe line to Dow and Polymer, and three sets of meters on materials returned to the refinery by them. The meters are installed dually so that each meter can be checked by its mate. Any meter may be removed from the line without disturbing the others. Calibrated meter runs are provided to insure the greatest possible accuracy.

The building, housing the principal pumping equipment, is divided into three distinct compartments, each adequately heated, ventilated, and fully equipped with fire protection devices.

Large inspection sumps are provided in them and the remaining two process unit groups, to permit immediate diversion of effluent water to the oil separators. Suspected streams of water that may contain traces of oil are continuously diverted to the oil separators before delivery to a creek that cuts across the west end of the refinery. Noxious or undesirable gases that might contaminate the atmosphere are destroyed by burning.

A very modern laboratory has been constructed and equipped for the chemical and research staff and houses the test engines, gas analysis equipment, and all other equipment necessary to successful operation. Nothing has been spared to insure the utmost in quality control and the development of new products and better methods of processing as time goes along.

Due to lateness of completion of the laboratory and the usual plant shakedown period, it is too early to table test data showing the effects to be achieved by varying the processing conditions. So far, the activities of the staff have been confined to product specification control, the many ramifications of inter-plant gas transfers, and general organization matters. To date all products have more than met the most rigid specifications and not a single complaint on product quality has been heard.

In order in insure against such contingencies as international agreements, a failure in the Inter-Provincial Pipe Line system, or the Great Lakes transportation system, an 8-in. crude oil pipe line has been laid from the refinery, connecting with the network of pipe lines in the United States. A 4-in. pipe line also links the new refinery with storage and shipping facilities still retained at the old refinery site in Petrolia.

Utility Systems

With the exception of the steam generated in the waste heat boilers at the catalytic cracker, all steam used in the refinery is generated in one of two B. and W. and Goldie McCullock boilers. Each boiler has a capacity of 100,000 lb of super-heated steam per hour.

The principal use of steam is for operation of the process unit groups and to maintain the required fluidity of heavy products in storage tanks. A portion of the condensate form from the steam is returned to the boilers and the balance made up with carefully treated water. The boilers and principal auxiliary equipment are housed and can be operated during a power failure.

A central refinery air-supply system is located within the boiler plant consisting of separate air-compressors for instrument air that is carefully dried. A separate group of air-compressors is provided for maintenance and special services in the refinery. A spare group of compressors provides either instrument or service air under emergency conditions.

The water supply system is an interesting feature of the refinery. Drinking water is obtained from the city of Sarnia, through a main approximately 15,000 ft in length. For process cooling-water the untreated river water, rarely above 70 F is used.

A seven foot tunnel connects the shore intake to the main pumphouse, where three vertical motor-driven pumps are installed, each of 8000 gpm capacity. Water is delivered through a 36-in. steel main directly to the units. From the main the water is drawn for the steam boilers and processing at the refinery.

The process wash-water is clarified in the precipitator, together with the boiler feed water. Motor-driven pumps deliver the process wash-water in a separate main and the boiler-feed is filtered, softened and pumped to the boiler plant.

Chlorine for slime control is injected into the 36-in. main beyond the take-off for process water. All such equipment is in a separate building adjacent to the steam-plant.

For fire protection, in addition to the chemical apparatus, there is a separate loop-main with fire hydrants throughout

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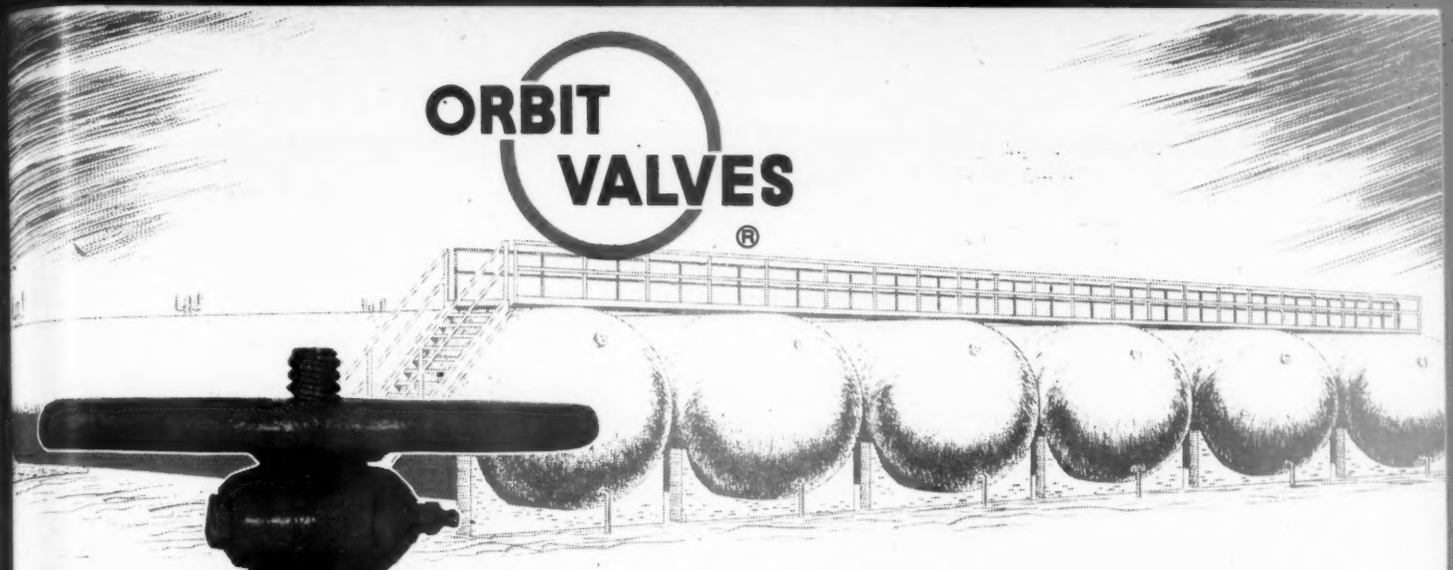

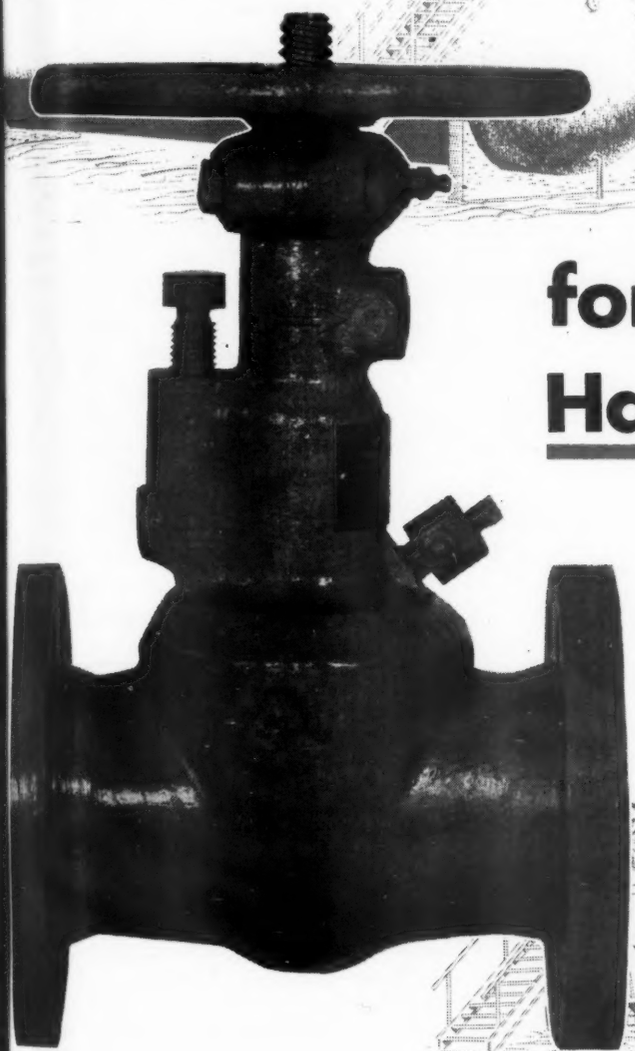

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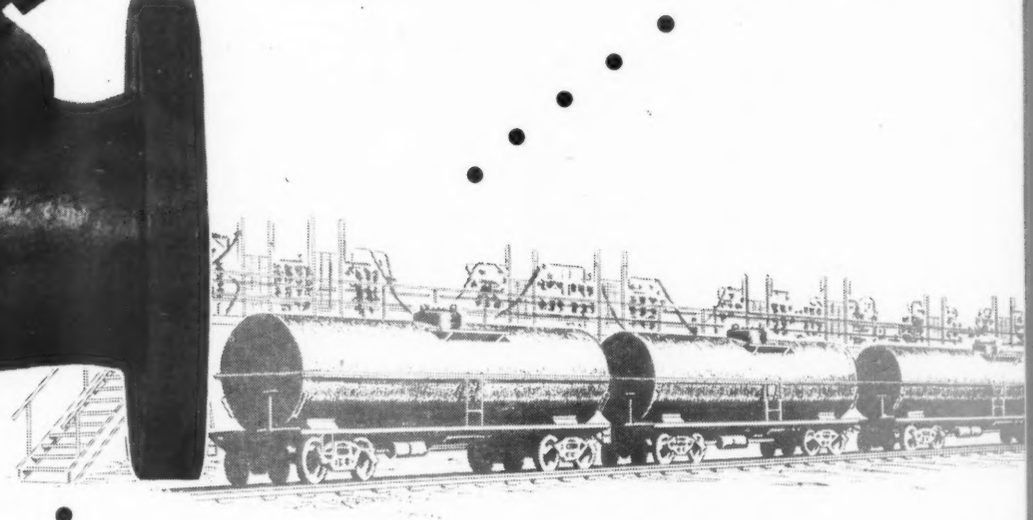

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the plant. An electrical-driven pump in the water treatment building draws water from the 36-in. main and boosts the pressure to the required limit. As a standby, in case of power failure, there is a vertical diesel engine-driven pump at the main pump house. A study of the water supply reveals that there are five different water supplies in this refinery, i.e., city domestic, river cooling-water chlorinated, process water clarified, boiler feed filtered and softened, and fire protection raw river water.

A feature of the cooling water supply is a 250,000 imperial gallon elevated water tower, which maintains a constant pressure on the cooling water lines and affords additional protection in emergencies.

The drainage system is unique in that it consists of four separate sewers for the following:

1. Sanitary sewage carried to a septic tank and double-drain sand bed.

2. Storm water to the river with provision for low flows diverted to the waste treatment plant.

3. Cooling water subject to oil contamination to the waste treatment plant.

4. Cooling water with no oil contamination hazard to the river. The sizes of sewers range from 12 to 48 in. in diameter.

To remove any waste oil from the various streams, a new type of waste treatment plant was built. This plant consists of two circular concrete tanks 80 ft in diameter and 8 ft in depth, with conical shaped bottoms. Drainage water containing waste oil is delivered to a riser pipe with baffle in the center of the tank from where it flows radially to a circumferential weir after passing under a six-foot deep baffle-plate, also circumferential. The waste oil floats to the top of the tanks and is decanted off the surface by mechanically adjusted decanters and pumped to the slop tanks for recovery.

Undiluted viscosity broken crude oil residue produced, in the crude distillation unit is normally used as fuel oil by the refinery itself. The oil is pumped through a looped pipe line, to insure continuity of operation. A further precaution includes the instantaneous service of a spare-pump in the event of failure of the main-pump. Oils reclaimed, and not suitable for processing, are delivered in a separate pipe line for disposition in the boiler house. A gathering system of pipe lines accumulates the residue gases from the process units and Dow Chemical and delivers them under pressure to the process-units and boiler-house, for additional heat. Excess gas is automatically discharged to the flare-stack, where it is burned.

Adequate handling facilities are provided for the various catalysts, treating chemicals, inhibitors, dyes, anti-knock fluid, and dryers required for the refinery with minimum manual effort.

The principal chemical used is caustic soda, which, being soluble in water, is specially treated in a novel process utilizing carbon-dioxide from the catalytic cracking unit. The treatment converts the spent caustic to an oily liquid which is carefully separated and burned in boilers and the remaining caustic is changed to harmless salt.

All electricity for power and lighting is supplied by the Hydro Electric Power Commission of Ontario. A dual or looped system feeds the refinery with power made available from three independent sources for maximum reliability.

A sub-station transforms the high voltage to more suitable voltage before distribution in an underground duct system. Distribution is radial and not looped to the various users. The sub-station contains a dual set of transformers, which are interlocked to permit automatic transfer from one transformer to the other in the event of failure of one. The power received at the area of use is further reduced by transformers to the voltage required by the equipment or lighting.

The system is completely explosion-proof in all areas considered hazardous. A small emergency steam turbine-driven generator, installed in the boiler house, provides lighting and power to operate control instruments in the refinery, in case of emergency.

Relief valves are provided on all pressure vessels. These are piped to a flare-stack and any light vapors burned automatically. Heavy oil vapors and liquids are piped to a separate quench-tower, which liquefies the vapors automatically by means of water. A pump returns the oily water to special tanks for recovery of oil.

A complete pipe-loop system encompasses the refinery with water for fire-fighting. Water is made available under high pressure from the motor-driven pump operating from the elevated water-tank and the cooling process water system. A spare diesel-driven fire pump supplements the main pump. Adequate foam systems are installed for the protection of all tanks and to handle fires within the process units. Portable chemical fire extinguishers are located at strategic points in the various buildings, or steam snuffing is provided.

Complete water-spray systems are installed in the anti-knock fluid storage building. Buildings not otherwise protected have sprinklers.

The Fire Station building houses a mobile fire engine, foam trailer carts, a patrol jeep, hose and drums containing foam liquid compound and dry chemical. For convenience an auxiliary building at the opposite side of the refinery supplements the hose and chemical contents of the Fire Station.

All important points of the refinery are closely knit together by means of an enunciator and an automatic telephone communication system, which permit contacts with the outside. Separate systems to Dow and Polymer permit direct communication with strategic operating points in the refinery. In the event of an emergency, an independent network permits transmission of instructions to personnel at selected points.

The refinery is laced with roads, streets and access ways. All roads are elevated to permit the crossing of pipe lines which are laid on specially designed and patented supports near the ground.

A railroad siding services the refinery's shipping and materials requirements. Three pipe supporting bridges were found necessary to carry the many pipe lines across Talfourd Creek to and from the Water Pump House and the other river front facilities.

Training Program

During the planning stages of the project it was realized that additional engineering, technical, and supervisory personnel would be required as well as operating personnel. Shortly after the commencement of construction this technical and supervisory staff were acquired and gathered together at Petrolia, the site of the old refinery, in a classroom specially prepared and equipped with files, desks, tables, drawing racks, blackboards, etc. Preliminary sessions were held under the guidance of E. A. Smith, manager of manufacturing. Later the program was directed by Dr. K. A. West, production superintendent, and V. M. Norwood, the plant manager.

Preliminary discussions were held with the contractors' engineers concerning the various processes. This was followed by actual observation of the operations of similar processes in refineries both in Canada and in the United States.

The remaining step-by-step program included the preparation of a larger classroom in temporary buildings at the new refinery, where additional equipment, such as a projector, blue-printing machine, and special wide armchairs for the operating personnel was provided. The technical and supervisory personnel then took over the lecturing and teaching of the operating personnel, and consisted of:

1. Intensive blackboard instruction.

2. Study of flow diagrams with attendant motion picture films.

3. Additional discussion with contractors' engineers concerning the written operation instructions and safety measures.

4. Detailed study of all mechanical and control features of the entire refinery.

5. Participation in preliminary and eventually full operation of the various components.

New Projects in Planning Stage

Government and petroleum industry leaders estimated last year that Canada needs 100,000 bbl per day of additional refining capacity. Canadian Oil's new plant will supply one-fifth of that deficiency. Indications are that the entire output of the new refinery from the first full production day will be required for civilian and defense uses.

Purchase of land for expansion, even before levelling of the adjoining refinery site began was an application of Canadian Oil's policy of long-range planning. In short perspective, the firm's feat in more than doubling its capital assets in a little more than two years may foreshadow new construction and expansion projects already under study. * * *

Construction to begin soon on large expansion program of Shell's Vancouver refinery.

Shell Oil to Expand Its Vancouver Refinery

A $10,000,000 expansion of the Vancouver refinery of Shell Oil Company of Canada, Ltd., was announced by W. M. V. Ash, president.

Construction will begin this fall, and plans call for completion in late 1953. This will coincide with completion of the Trans Mountain Oil Pipe Line.

Shellburn refinery is situated on Burrard Inlet, in the Vancouver suburb of North Burnaby. At the present time most of the crude oil refined here is imported by tanker from California. With the Trans Mountain Pipe Line in operation, California oil will be replaced by Canadian crude, Ash said.

The multimillion dollar expansion will more than double the present refining capacity, bringing it to 15,000 bbl a day. Included is the construction of a fluid catalytic cracking unit of latest design, a vacuum flasher, gas recovery plant, polymerization, and treating units. New office buildings and shops will be constructed and tank storage for refined products will be increased by 300,000 bbl.

The original refinery at Shellburn was built in 1932 and had a capacity of 5000 bbl daily. In 1946 the company carried out an expansion program and again two years later Shellburn was enlarged with installation of thermal cracking and polymerization units.

New Mileage Record Set

Shell Oil Company's research laboratory teams completed their 1952 marathon race for mileage and set a new record, this time of 168.47 miles per gallon of fuel. This is a contest held each year by the research staff looking toward the extension of mileage records for motors cars. The previous record was made in 1949 by R. J. Greenshields, research director for the laboratory, with 150 miles per gallon.

This year's record was set by a 1924 Chevrolet in the hands of Dave Berry and Fred Schuette. The methods used by all the contestants are not for the typical motorist, but can be employed only by experts under special conditions. The car fuel and ignition systems are tuned to the Nth degree for efficiency; tires are blown up to 100-110 psig, treads cut off except for a narrow center band; fans, generators, etc., are disconnected. The test course is studied for weeks to determine where to coast and where to speed up, where to travel at the most efficient speed, and what those speeds are to be. A new car class was added this year, cars with automatic transmissions, required to maintain at least a 30 miles per hour average speed. All rules governing the contest are strict and rigidly adhered to by the contestants.

Research Lab Underway

Jefferson Chemical Company, Inc., announced that construction has begun on a half-million-dollar addition to its research laboratory facilities at Austin, Texas.

The larger of the new buildings will ultimately provide bench-scale research facilities for about 50 chemists, to be employed gradually over the post-construction period. New facilities will expand the investigation of petroleum-based chemicals carried on at Austin Laboratories.

Designed by Kuehne, Brooks and Barr, Austin architects, the buildings are being erected by the Leslie Crockett Construction Company, also in Austin.

New Units to Be Installed In Carter Montana Refinery

The Carter Oil Company has awarded a turnkey contract to chemical plants division of Blaw-Knox Company for the design, procurement, and construction of a catalytic polymerization unit and a waste heat boiler auxiliary to the present catalytic cracking facilities. These units will be installed at the Carter refinery in Billings, Montana.

The polymerization unit is to be a high pressure shell and tube type reactor unit employing solid phosphoric acid catalyst. Feed to the unit will be 3,700,000 std cu ft per day of cracking plant gas. Product will be 600 bbl per day of 110-plus octane polymer which will be used for blending premium grade motor fuels. This unit is scheduled to be on stream early in 1953.

Frontier Oil to Get New Type Compressors

For a new catalytic cracking plant being built for Frontier Oil Refining Corporation at Tonawanda, New York, the first of its high speed balanced opposed compressors to be driven through gear reduction sets by explosion proof motors, will be supplied by Worthington Corporation.

The balanced opposed frame is so constructed that no inertia forces are transmitted to the foundations. This design originated with Worthington in 1931. The frames being built for Frontier incorporate many features not available in the earlier designs. For instance, all main bearings and crankpin bearings are of the so-called precision type, centrifugally lined with a thin coating of babbitt. All working parts are bathed in oil from a forced feed system.

How would you like to spend the hottest day of the year running a lot of furnaces? That's the way these scientists spend it, in Shell's unique oil burner laboratory at Sewaren, New Jersey. They toil right through the summer to find ways of making oil heating more efficient and convenient for you next winter. Thanks to progress growing out of research such as this, it takes only about one-half as much oil to heat the average home as it did 30 years ago.

Ohio Oil Company to Get New Houdriforming Unit

Contracts for the installation of a Houdriforming unit at The Ohio Oil Company's Robinson, Illinois, refinery have been awarded to Houdry Process Corporation of Philadelphia, according to C. G. Kirkbride, president of Houdry. This catalytic reforming unit, having a nominal charging capacity of 8000 bbl per day, is designed primarily for the production of high-octane gasoline. Construction will be done by Catalytic Construction Company under the direction of Houdry. Completion of the work is scheduled for late 1953.

Computer Conference Set

The first meeting of the Western Computer Conference will be held at the Hotel Statler in Los Angeles, California, February 4, 5, and 6, 1953. This conference will be sponsored by the joint Computer Conference Committee of the Institute of Radio Engineers (IRE) and the American Institute of Electrical Engineers (AIEE).

Papers to be presented at the conference will appeal to both prospective users of electronic computers and to the designers of these instruments, according to the co-chairman, Dr. Gilbert McCann of the California Institute of Technology and Dr. Harry Huskey of the National Bureau of Standards at UCLA. Information presented will be equally divided between application and design problems and will cover both analog and digital computers.

Standard Cal to Build New Cat Cracking Unit

Standard Oil Company of California will build a new catalytic cracking unit at its El Segundo, California, refinery at a cost of more than $20,000,000 it was announced by T. S. Petersen, California Standard's president.

Petersen said engineering work on the El Segundo project will begin immediately. Actual construction is expected to begin in mid-1953 with completion scheduled for 1954.

The new unit will include a feed stock preparation unit capable of handling 54,000 bbl daily of heavy fuels. It also will include facilities to recover H_2S gas for conversion into sulfuric acid. Recovery of this gas will be another step in California Standard's long standing program to avoid air pollution.

Petersen said the new project will be one of the most complex ever constructed by California Standard. He pointed out that one of its derivatives will be used in the manufacture of a compound called cumene at a separate unit to be built in 1953 at El Segundo.

Sinclair Builds New Propane Fractionator Unit

Construction of a new, 700 bbl per day propane fractionating unit will be begun shortly by Sinclair Refining Company at its Wellsville, New York, refinery, according to announcement by W. B. Chenault, Sinclair general superintendent at Wellsville. The new unit will operate on Pennsylvania steam refined 600 flash stock to yield three resin streams and Pennsylvania grade bright stocks.

It is engineered so that while operating on Pennsylvania stocks normally, it will operate as well on fractions from Mid-Continent crudes. On local stocks the first step will be treatment with propane in a primary fractionator yielding a deresined oil and a wide resin cut that is taken from the tower bottom to a secondary fractionator from which a mixed resin stream is taken overhead, and a heavy resin bottoms is withdrawn. The overhead stream is split similarly into a light and an intermediate product. The viscosity of these streams ranges from 500 SSU seconds to 30,000 sec at 210 F. In order to make the high viscosity resin a refrigeration unit controls temperature at the bottom of the secondary fractionator.

Clearance of the area where the unit will be situated has been completed and the site is being put into shape to start construction. The unit's cost is expected to be approximately $1,000,000; it will be constructed by Fluor Corporation of Los Angeles, and is expected to be in operation by the spring of 1953.

Electronic Refinery Unit Operating in South Wales

A new sulfur dioxide extraction plant commissioned late in 1951 by National Oil Refineries, Ltd., Llandarcy, South Wales, to produce premium grade kerosine, is believed to be the first refinery plant in the world to be completely controlled electronically. This plant, which has since been in successful operation, is part of the Anglo-Iranian Oil Company's large development program in the United Kingdom, which marks a considerable advance in instrumentation and process control.

Electronic measuring and control instruments which are used exclusively in the plant for flow, pressure, and level, operate on the Evershed electronic repeater system and have been manufactured by Evershed and Vignoles, Ltd., London. The advantage of electronic operation as opposed to pneumatic systems previously employed, lies in the fact that the response is virtually instantaneous irrespective of the distance between the plant and the control room. Time lags due to the compressibility of air in the transmission lines — an inherent disadvantage in any pneumatic control system — are therefore eliminated, and any deviation from the required quantities of flow, pressure or level is detected and corrective action is applied instantaneously. The main development is Evershed Process Controller.

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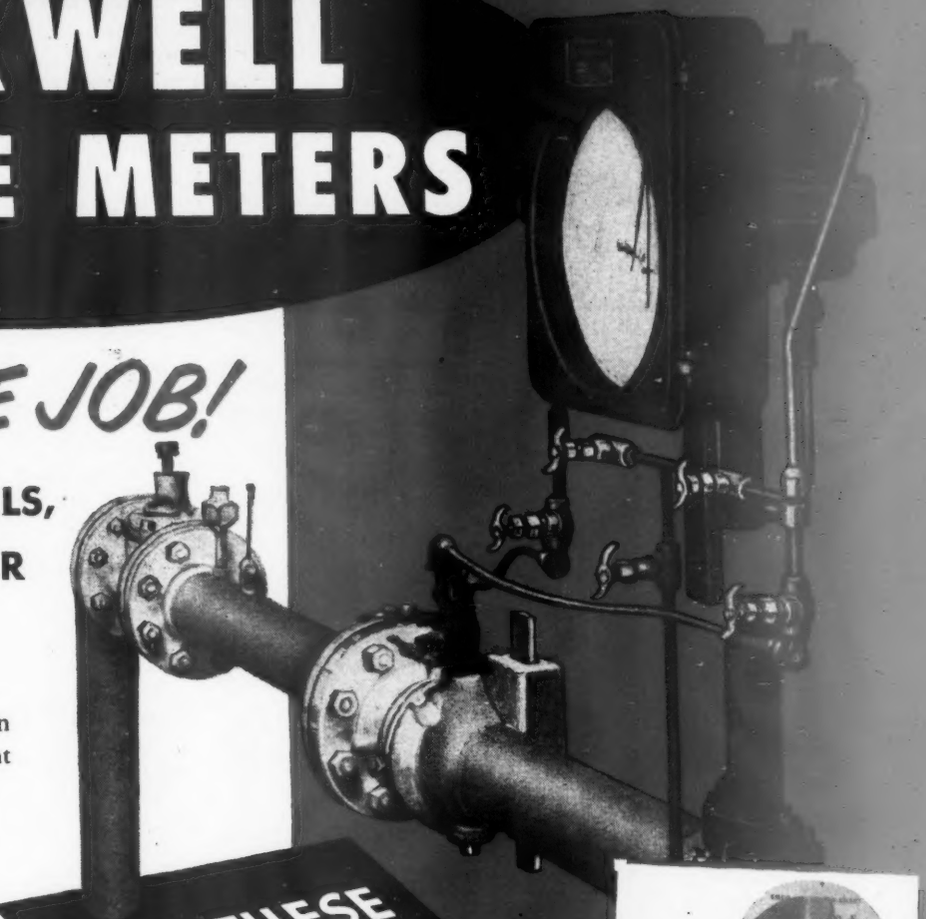

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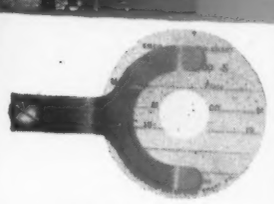

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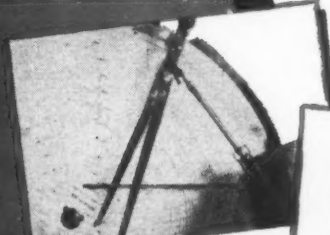

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New Refinery Device Announced by Shell

A new device that increases, at low cost, the capacity of petroleum refineries, is now offered under a license to the entire oil industry by Shell Development Company, it was announced by M. E. Spaght, president.

The new device is known as the "Turbogrid" distillation tray, and consists of an open-grid structure of simple design, for installation in "fractionating columns" — the giant towers that rear like skyscrapers above a modern refinery. According to Dr. Spaght, they are "the first basic improvement in distillation trays in a quarter-century."

Anglo-Iranian Plans Middle East Refinery

Anglo-Iranian Oil Company executives are now at the Port of Aden on the Red Sea to discuss with the Aden Government plans to build a 100,000-bbl a day refinery there. The cost of the refinery is estimated at between $112,000,000 and $140,000,000.

The party is headed by J. M. Pattinson, a managing director of the company. Accompanying him are C. E. Spearing, general manager of Anglo-Iranian's refineries department, and other members of the company's staff.

The refinery, which would take about two years to build, would supply refined products to markets in the Red Sea area and in East and South Africa. A major part of the refinery's output would be used for bunkering ships at Aden. Both this trade and the African markets show a steadily increasing demand.

Southern Refinery Moves to Houston

A new company called Southern Refinery Engineering Company with engineering, purchasing, and construction facilities to serve the refinery and petrochemical industries of the Gulf Coast area has been moved to Houston, Texas, according to John H. Schurman, president of the new firm. Southern Refinery, making its headquarters in the M & M Building, will eventually employ approximately 100 engineers and office personnel in downtown Houston. The firm that does engineering and construction work will have in addition field construction crews to erect refinery and other industrial installations.

The principals of this new concern are John H. Schurman, president and general manager, who is also president of mechanical construction division in Huntington, West Virginia, an engineering and construction firm that operates in the Mid-Atlantic states. Tom M. Lumly, with headquarters in Tulsa, is vice president. Lumly is president of several construction companies operating in the Mid Continent area and in Canada, including Refinery Engineering Company of Tulsa. Secretary of the company will be L. E. Von Woglom who is moving from Huntington, West Virginia, to assume his new duties in Houston. Von Woglom formerly was chief engineer of mechanical construction division.

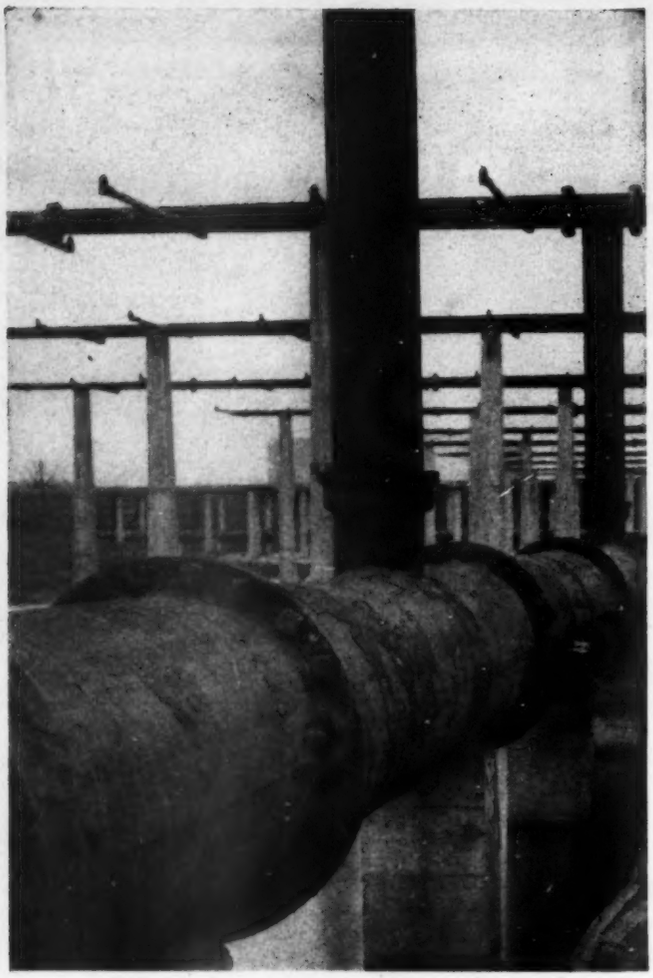
Variety of Subjects Planned for Meeting

The National Lubricating Grease Institute has announced subjects ranging from the latest type of additives that will permit greases to carry much higher loads with extended useful life to methods of grease manufacture in a continuous process will be discussed at its annual meeting October 27-29, at the Edgewater Beach Hotel, Chicago, Illinois.

The railroad's search for a roller bearing grease that won't congeal at low temperatures or run at high temperatures will be described from tests by the New York Central. They want a lubricant to last for periods of one to three years. Solution to the problem is being found through joint action by railroads and grease manufacturers.

The magic of silicones in greases that will withstand extremely high and low temperatures will be presented by the General Electric Company. Another wonder of modern lubricating grease manufacture is the lithium type that will resist both moisture and heat, rapidly growing in popularity to the point where they are now called "All-Purpose or Multi-Purpose greases." The current shortage and possibility of adequate supplies of this lubricant will be given by Foote Mineral Company.

The Air Force problem of developing proper greases that withstand the scorching heat of the desert or low temperatures encountered in high altitude flying will be discussed by a representative of the Wright Air Development Center.



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Proved long life and stubborn resistance to corrosion make cast iron pipe a contributing factor in lowering plant maintenance per barrel of crude. Replacing shorter-lived pipe with cast iron pipe has demonstrated this in many refineries. Cost per term of service decreases. Interference with production, caused by frequent replacements, ceases to be a headache. Cast iron pipe works hand-in-glove with plant management to keep maintenance cost down in many refinery operations. Available with bell-and-spigot, plain end and flanged, or with standardized mechanical joints. Cast Iron Pipe Research Association, Thomas F. Wolfe, Engineer, 1015 Peoples Gas Bldg., Chicago 3, Illinois.

CAST IRON PIPE
FOR LONG LIFE AND ECONOMY

Sinclair Chemical Set Up

To expand its operations further in the field of petrochemicals, Sinclair Oil Corporation has announced the formation of Sinclair Chemicals, Inc., as a direct subsidiary of the parent company.

The new organization will take over

John A. Scott

the production and sales of chemicals recoverable from petroleum raw materials heretofore handled by the petrochemical division of Sinclair Refining Company.

The new subsidiary, of which P. C. Spencer will be president, will utilize the research facilities of Sinclair Research Laboratories, Inc., but will also have its own research staff and market development department, the announcement said. John A. Scott, manager of the petrochemical division since its inception, will be executive vice president of the new company. E. W. Isom, chairman of the board of Sinclair Research Laboratories, Inc., and director of Sinclair research for more than 35 years, will be chairman. Headquarters of the new company will be in the Sinclair Oil Building, 600 Fifth Avenue, New York.

Pan-Am Research Building Underway in Texas City

Pan-American Refining Corporation recently broke ground at its Texas City, Texas, refinery for an extensive enlargement of its research and development facilities. L. W. Moore, president of the corporation, officiated at the ceremonies, assisted by Dr. Harold R. Snow, vice president, and Dr. P. C. White, manager of research and development. About 150 members of the Research and Development staff were present for the ceremony. Moore compared the support of the research and development activities of a company to an oil exploration venture in which a certain percentage of "hits" are required or the company finds itself out of business. Similarly, Technical Research Personnel are depended upon to score "hits" a reasonable percentage of the time in order to justify the support of their activities.

Only in this manner can competition be met and consumers assured of high quality products at reasonable prices. Commenting further, Moore emphasized that it is the responsibility of management to provide proper equipment and working space for research.

Stockdale Will Head New North Dakota Refinery

Thomas E. Stockdale has been promoted manager of Standard Oil Company's new refinery, which it had previously announced it plans to build at Mandan, North Dakota. Ford H. Blunck will succeed Stockdale as general superintendent of Standard's Wood River, Illinois, refinery. Dr. Blunck has been manager of the projects, capital expenditures, and contracts division.

Stockdale joined Standard Oil Company in 1923 as a designer and draftsman at its Whiting, Indiana, refinery. He was advanced to his former position in 1951. Dr. Blunck received his bachelor's degree from the University of Illinois and doctor's degree from Northwestern university

Meeting Dates Announced For NGAA Convention

The 32nd annual convention of the Natural Gasoline Association of America will be held April 29-May 1, 1953, in the Rice Hotel, Houston, Texas, according to a recent announcement from NGAA Tulsa, Oklahoma, headquarters. Plans for three regional meetings are now complete with the following dates: Blackstone Hotel, Tyler, Texas, October 24; Herring Hotel, Amarillo, Texas, November 21; and Scharbauer Hotel, Midland, Texas, February 27, 1953.

Kenya Refinery Planned

The government of Kenya has announced that Shell Oil Company will build a $112,000,000 oil refinery. This will be one of the largest in the world, and will be situated on the Kenya Coast opposite Mombassa Island.

Chemical Facilities Merge

To meet Canada's sharply rising demands for industrial chemicals and pharmaceuticals, North American Cyanamid, Ltd., has consolidated its several office and warehouse locations in Montreal into one newly constructed building where it will increase its scope of activities by producing pharmaceuticals and refining aureomycin. This was announced by K. C. Towe, president of the firm's parent company in New York, American Cyanamid Company.

ACS Abstracts

Radioactivity and the Origin of Petroleum

Irving A. Breger and Walter L. Whitehead, Massachusetts Institute of Technology, Cambridge, Mass.

Since 1942 the American Petroleum Institute has sponsored at the Massachusetts Institute of Technology a project to investigate the effect of radioactivity on the transformation of marine organic materials into petroleum hydrocarbons. To date it has been possible (1) to convert fatty acids into aliphatic hydrocarbons, (2) to convert a naphthenic acid into a cyclic hydrocarbon by means of alpha-particle bombardment, and (3) to produce gaseous hydrocarbons found in association with crude oils. Work is in progress to determine the relationship between the organic matter and radioactive elements in marine organic shales. Studies have also been carried out to establish the radioactivity of a number of important geological strata associated with crude oils.

The Chemical Nature Of Bitumens Obtained By Coal Hydrogenation

R. A. Glenn and C. W. DeWalt, Jr., Coal Research Laboratory, Carnegie Institute of Technology, Pittsburgh, Pennsylvania.

A comparison has been made from a chemical standpoint of two bitumens produced by coal hydrogenation: (1) *HOLD*-bitumen, the benzene-soluble portion of the heavy oil let-down taken from the hot catchpot at the Bureau of Mines, Louisiana, Missouri, plant during the hydrogenation at 471 C of Rock Springs, Wyoming, coal, and (2) *RHR*-bitumen, the carbon disulfide-soluble portion of the restricted hydrogenolysis residue from the cold-head bomb after hydrogenation at 375 C of Edenborn coal at the Coal Research Laboratory.

Solvent fractionation and molecular distillation were used to resolve these materials. Molecular weights, ultraviolet spectra, and ultimate composition (carbon, hydrogen, and nitrogen analyses) were determined for the fractions.

Both pyrene and coronene were easily identified in the *HOLD*-bitumen, but there was no evidence of any individual compound in the *RHR*-bitumen. The former product is the more aromatic of the two, as shown by its much lower hydrogen to carbon ratio.

The *HOLD*-bitumen is 76 per cent pentane-soluble; the *RHR*-bitumen, only 28 per cent. These solubility data, together with relative volatilities and molecular weights, indicate that the *HOLD*-bitumen contains much material of lower molecular weight than any found in the *RHR*-bitumen. All the data show that there is more high-molecular weight material and material of higher molecular weight in the *RHR*-bitumen in accord with the differences in the conditions of hydrogenation. It is concluded that the *RHR*-bitumen is probably a more primary product than the *HOLD*-bitumen.

PERSONALS

Wilbur S. Mount, manager of product engineering in Socony-Vacuum Oil Company's gasoline and fuel oil department, has been named manager of the aviation department.

At the same time **Warren L. Baker,** manager of the aviation department, will retire from the company.

A graduate of Lehigh University, Mount has devoted 20 years to the petroleum aspects of automotive, aviation and diesel engine fields.

James P. Thompson, assistant foreman of the North plant, Magnolia Petroleum Company's Beaumont, Texas, refinery, has been named assistant process superintendent in charge of oil movements. **Ralph Snover** replaces him in the North plant post, while **John J. Etheredge** assumes Snover's duties as catalytic cracking foreman. **Henry A. Landry,** unit operator, was promoted to Etheredge's former position of shift foreman.

L. C. Brunstrum has been promoted to section leader and **H. J. Liehe** to group leader, greases, in the Standard Oil Company (Indiana) research department at its Whiting, Indiana, laboratory; **A. W. Lindert,** section leader, and **R. S. Barnes,** group leader, industrial lubricants; **T. B. Tom,** section leader, and **R. A. Hunt,** group leader, light oils; **R. A. Dinerstein,** group leader, fractional distillation and hydrocarbon analysis; **M. Den Herder,** group leader, catalyst research; and **J. W. Mohlman,** group leader, information services.

In the technical service divisions **M. Gordon,** section leader, light and heavy oils finishing and asphalt manufacture; **W. E. Stanley,** group leader, light oils finishing; **R. B. Selund,** section leader, distillation, coking, heavy oils processes, and acid manufacture; **W. E. McGinnity,** group leader, heavy oils processes and acid manufacture; and **E. R. Walter,** section leader, and **G. M. Goodman,** group leader, economics.

A. A. Harban has been appointed group leader in the chemical products division at Standard Oil Company's Whiting, Indiana, research laboratory. Dr. Harban joined Standard in 1948 as a chemist. He did his undergraduate and graduate work at Purdue University.

Leslie D. Carver, director of technical service, Witco Chemical Company, carbon black division, has gone abroad for approximately two months. He will visit the various branches and agencies of the Witco Chemical Company throughout Europe. Carver has been invited to address several meetings of European rubber technicians.

Joseph L. Stecher, assistant director of sales of Du Pont's petroleum chemicals division, has retired after a 37-year career with the company. He had been connected with tetraethyl lead production and sales almost continuously since 1923, the year the first tetraethyl lead anti-knock compounds for gasoline were marketed. Stecher attended Drexel Engineering College and joined Du Pont in 1915 as a laboratory assistant at the experimental station.

Francis M. Pate has been promoted from plant foreman of the Seeligson gasoline plant to an assistant superintendent of Magnolia Petroleum Company's Vanderbilt, Louisiana, District. In that capacity he will be in charge of the Vanderbilt gasoline plant and other gas interests in the Vanderbilt and Luling area.

Charles A. Freeman, plant foreman at Magnolia's Sholem-Alechem gasoline plant near Healdton, Oklahoma, has been transferred to plant foreman of the Seeligson plant.

A. P. Lobrecht, district engineer of the Healdton natural gas district, has been made plant foreman at Sholem-Alechem.

Arthur H. Boultbee has been appointed manager of manufacturing research for Shell Oil Company, it was announced by F. S. Clulow, vice president. He will replace **D. L. Yabroff,** who is returning to Shell Development's research laboratory at Emeryville, California, as associate director in charge of chemical products.

Dr. Boultbee obtained his PhD in chemical engineering from the University of Toronto and then studied at the Imperial College of Science and Technology in London, where he was granted a D.I.C. in chemical technology. He joined Shell Oil Company as a chemist at Martinez refinery in 1935. Since then he has served at Shell's other California refinery at Wilmington and in the San Francisco office.

Dr. Maurice J. Day, metallurgical engineer at U. S. Steel Company, Pittsburgh, Pennsylvania, has been named manager of the materials and processes division at Armour Research Foundation of Illinois Institute of Technology. Dr. Day's appointment as one of three division managers was announced by W. E. Mahin, director of research.

He succeeds **W. A. Casler,** who has been acting manager of the division since May, 1951. Casler continues as assistant director of research and manager of program development.

As manager of the materials and processes division, Dr. Day will direct research and development activities of 300 scientists and administrative personnel.

He attended Michigan State College, Lansing, Michigan, where he received his PhD degree in physical chemistry in 1937, MS degree in electrochemistry in 1935, and a BA degree in chemical engineering in 1934.

Boyd F. Koepke

Boyd F. Koepke is back on the job at his Kansas City, Missouri, office of Aluminum Company of America, after an absence of several months. Boyd is well known throughout the oil, gas, and chemical industries especially throughout the midwest and southwest, where for years he has been working with these industries in the use of aluminas, for dehydrating and for catalytic applications, as well as with aluminum tubing for many plant and laboratory applications. He looks fit and in good shape after his long rest and is swinging rapidly into full time work.

Dr. Louis Lykken of Shell Development Company has been appointed manager, technical service, Julius Hyman and Company, Denver, recently purchased by the Shell Oil Company. Lykken has been assistant head of the analytical department at Shell Development for the past eight years.

He obtained his BS degree at the South Dakota School of Mines and Technology in 1927, and his PhD in physical chemistry at Iowa State.

Edwin F. Nelson has been named president and general manager of Lake Superior Refining Company. Nelson was former vice president of Universal Oil Products Company.

John W. Gendron has been appointed manager of the crude and products department of the western division of Tide Water Associated Oil Company, with headquarters in San Francisco. A graduate of the University of Oregon, he also studied law at Georgetown University and the University of San Francisco.

William Wishnick has been named to the position of assistant to the president. Witco Chemical Company, **J. J. Tumpeer** to national asphalt sales manager, **B. W. Lewis** to midwest asphalt sales manager, **J. A. Raggio** to eastern asphalt sales manager, **W. F. Twombly** in charge of product development, **J. H. Wishnick** to manager of Chicago and Lawrenceville plants, and **Stanley Trimble** to controller.

Thomas J. Starkie is now national chemical sales manager, **E. F. Wagner** is assistant national chemical sales manager, **C. A. Damen** is assistant vice president in charge of the Washington office, **M. A. Minnig** is national sales manager of rubber chemicals with **H. Brubacker** as assistant national sales manager of carbon black.

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Color of Lubricating Oils

DEAN R. MANNING*

The Lumetron Colorimeter† with accompanying filters has been used as a convenient instrument for determining the ASTM color of lubricating oils and the Saybolt color of waxes. The ASTM procedure for color determination of lubricating oil involves matching the color of a sample of oil with a glass color standard. In this procedure there is only one expression of color intermediate to the standard colors. This is expressed in terms of the darker standards as "lighter than" or "minus." In clay-contacting lubricating oils, it is desirable to have a means of obtaining a closer definition of color, in order to insure meeting specifications without, at the same time, over-treating the oil unnecessarily, with the attendant higher clay costs. For example, if it is desired to control a bright stock stream at 5 minus color to meet a maximum specification color of 5 ASTM, such a stream could vary from an actual 4.55 to 4.95 color and would be reported as 5 minus on all samples by the laboratory, if the ASTM procedure were used for control work. For proper control and economy, it might be desired to control the stream at 4.8 ASTM color. Measurement of color in 0.1 ASTM color point increments can be done easily by the Lumetron Colorimeter, which employs a photoelectric cell as the measuring element. The use of this instrument reduces errors, as no matching of color discs is required by the human eye except in establishing the original calibration curve. Another advantage, in some cases, is that a smaller sample is adequate. Thus far, this method has been used for bright stock and 650 neutral oil color control.

A calibration curve was prepared for bright stock, using a sample of bright stock having exactly 4 ASTM color and a sample having exactly 5 ASTM color, assuming linear color blending characteristics to prepare blends corresponding to 4.2, 4.4, 4.6, and 4.8 ASTM color. The per cent Lumetron light transmission was determined on each of these blends and plotted against the corresponding color (calibration curve — Fig. 1). The M-660 (Red) Lumetron filter was found to give the greatest spread in per cent transmission; therefore, the greatest sensitivity for bright stock. Standard 10 mm sample cells were used as they gave better repeatability than colorimeter test tubes.

It was necessary to prepare a separate calibration curve for 650 neutral oil as its predominant color is yellow instead of red, and also as it covered a different color range. The curve was prepared in the same manner as before, using blends made to cover the desired color range (Fig. 2). The M-515 (Green) Lumetron filter was found to be most suitable for this stock; 10 mm sample cells were used.

These methods rely on the assumption that the hue of all stocks of a given ASTM color is identical. This is probably true for a particular grade of oil produced in a given plant. It may be necessary to check the curve occasionally against the ASTM Union colorimeter on current production. This allows a correction of the curve for any change in hue.

As these methods are a measure of light transmission, it is obviously necessary that the sample be free from any type of haze. If moisture is present it will be necessary to dry the sample. This can be accomplished by heating under a vacuum or heating the sample and stripping with carbon dioxide.

The Lumetron has also been used for the determination of the Saybolt color of waxes. This has proved especially advantageous in experimental work on waxes, as the Saybolt color can be determined on a much smaller quantity of sample. The M-420 (Violet) Lumetron filter was used, and for convenience the standard colorimeter test tubes were used instead of 10 mm cells. It is obviously necessary to heat the test tubes in order to keep the wax completely melted during color determination.

The calibration curve was constructed in the same manner as previously described, from blends of waxes of known color. The wax color curve is essentially a straight line as there is no appreciable change in the hue with an increase in color, but, instead, an increase in intensity, (Fig. 3). The oil color curves, especially the 650 neutral oil, deviate from this because the hue tends to change from a yellow-green to orange-red as the color increases.

The instrument must be standardized against distilled water before each color determination, and the usual colorimetric precautions observed. The Lumetron was used for this work, but a spectrophotometer (or any similar instrument in which wave length of transmitted light can be controlled) could be adapted.

It should be remembered that the ASTM procedures are standard for specifications, and that these methods, while based on the standard ASTM colors, are merely supplements for closer control of plant operations.

* * *

*Cit-Con Oil Corporation, Lake Charles, Louisiana.

†Model 402-E, Photovolt Corporation, New York City.

FIG. 1. Bright stock calibration curve.

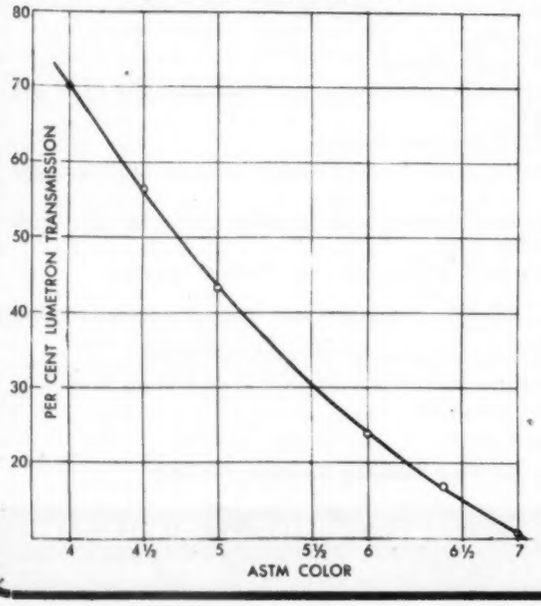


FIG. 2. 650 neutral calibration curve.

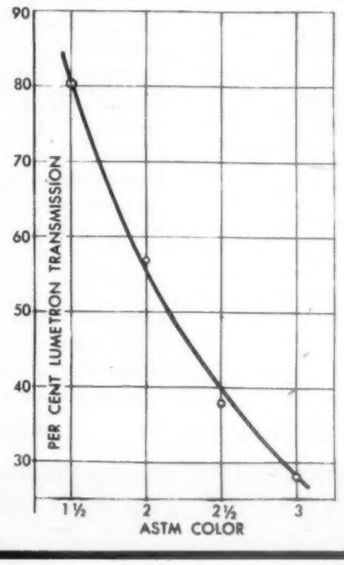
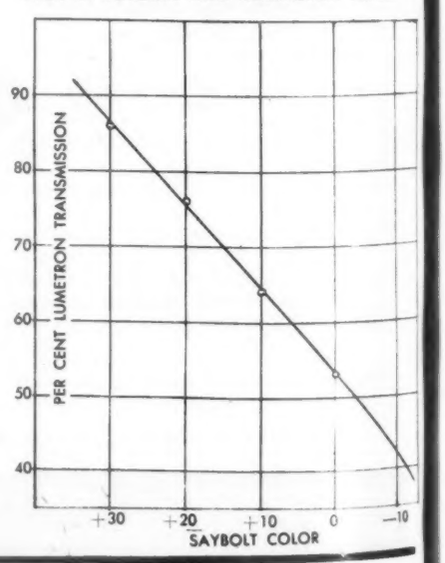


FIG. 3. Paraffin wax calibration curve.



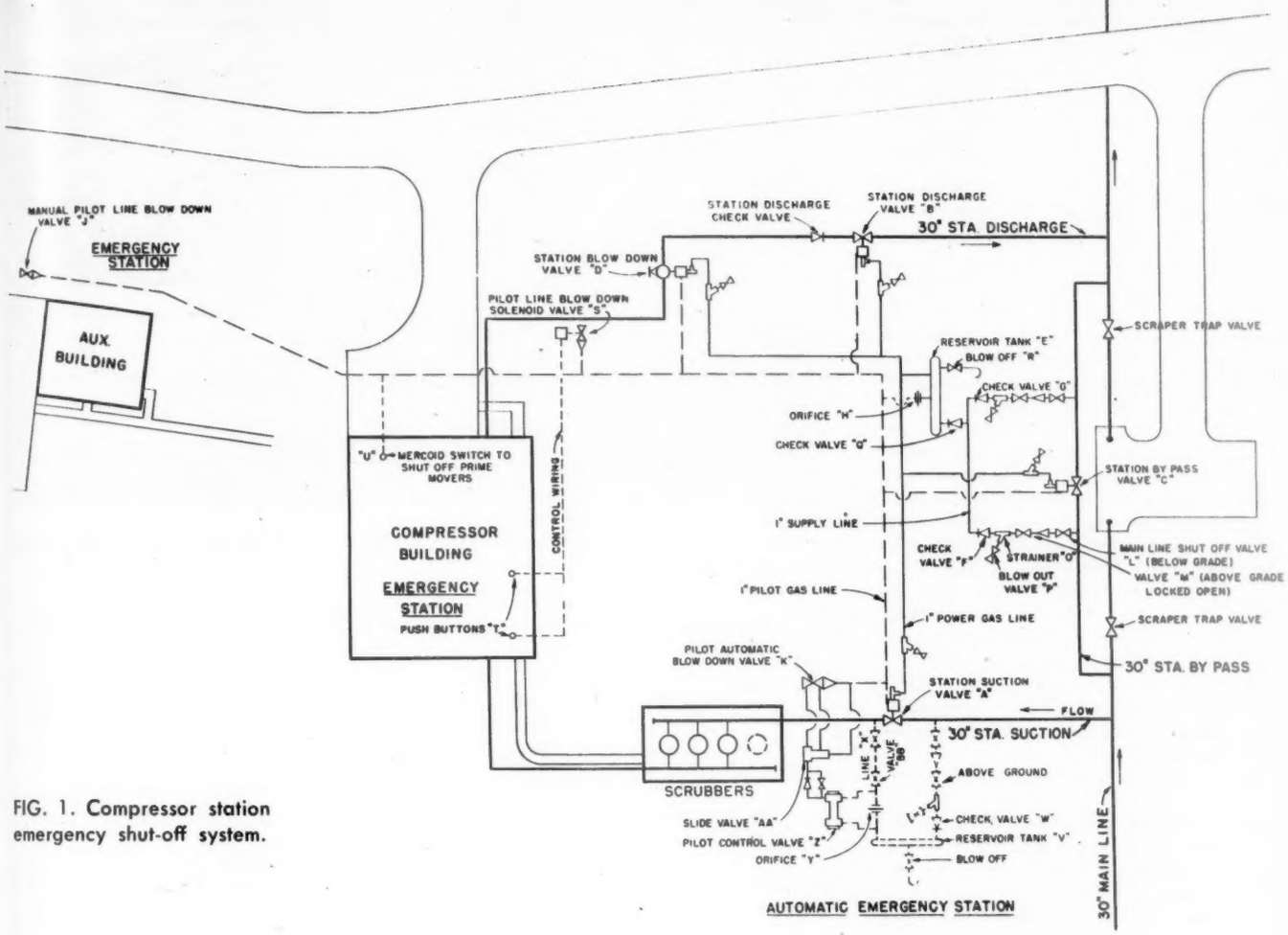


FIG. 1. Compressor station emergency shut-off system.

Compressor Station Emergency Shut-off

Design and basic principles of system installed by Texas Eastern Transmission on its 10 new stations

C. W. MARVIN

A CURRENT trend in cross-country natural gas transmission pipe lines is toward valve operators, either manually, remotely, or automatically controlled. This is evidenced in the following vignettes of operator usage by a few of the companies.

At the time of the survey, the Mississippi River Fuel Corporation had six new compressor stations with a total of 12 Nordstrom piston operators on 20-in. and 24-in. valves, all rigged for automatic emergency station shut-off. The Panhandle Eastern Pipe Line Company had 97 valve operators on its system. Nine of these were electric motor-operated; the rest were gas-operated and were on valves that range in size from 12 in. to 24 in. All Panhandle's valve operators were rigged for emergency operation except eight at a dehydration plant, which were installed on 12-in. valves for convenience only. The Transcontinental Gas Pipe Line Corporation had 78 gas-operated Limitorque operators and 7 electric-operated operators. They were variously on 30-in. by 20-in. WKM gate valves and 24-in. WKM gate valves and 30 by 24-in. plug valves. All these valves except 4 were compressor station valves. The 4 mainline valves are in heavily populated areas as a safety precaution. The Tennessee Gas Transmission Company was currently installing 8 operators per compressor station on some 22 stations. They are for the emergency closing of 2 suction and 2 discharge valves and to open 4 corresponding blow-off valves at each station. The main valves are 24 in., 26 in., and 30-in. plugs. The Trunkline Gas Company was employing operators at 8 compressor stations on the suction and discharge valves for an automatic emergency shut-off system.

The Texas Eastern Transmission Corporation has 14 E-I-M operators in sizes from 6 in. to 24 in. on mainline gates or as blow-downs. There are 195 Limitorque operators from 6 in. to 26 in. acting either as convenience operators on head gates or on station valves for

EXCLUSIVE

TABLE 1.

Valve size, in.	Valve type	Manufacturer	Operating pressure, psig	Number men operating	Closing time
6 x 4	Gate	WKM	...	1	55 sec
6	Gate	WKM	710	1	60 sec
8 x 6	Gate	WKM	...	1	60 sec
8	Gate	WKM	710	1	1 min 37 sec
10	Gate	WKM	711	1	1 min 12 sec
12	Gate	WKM	...	1	1 min 40 sec
16	Gate	WKM	710	2	3 min 42 sec
20	Gate	Allis-Chalmers	...	2	7 min
20	Gate	WKM	750	1	12 min 20 sec
24	Gate	Darling	...	2	10 min 37 sec
30	Gate	WKM	...	4	21 min
6	Plug	Walworth	710	2	3 sec
6	Plug	Nordstrom	...	1	10 sec
8	Plug	Nordstrom	969	1	25 sec
12	Plug	Nordstrom	487	1	55 sec
16	Plug	Nordstrom	460	1	40 sec
24	Plug	Walworth	...	2	2 min

automatic emergency shut-off. Sixty-two Nordstrom piston operators are also employed on 20-in. and 24-in. plug valves as automatic station emergency shut-offs. One river crossing is protected by 4 automatically controlled valve operators. Thus, a total of 275 operators were already installed on the Texas Eastern system prior to its recent 30-in. pipe line expansion program. For that program 187 E-I-M operators in three sizes were employed on valves from 8 in. in size to 30 in. Approximately 50 per cent of these operators are on 30-in. full-opening WKM mainline gates. In addition, 41 Shafer operators for plug valves from 6 in. to 30 in. by 24 in. have been used on automatic shut-off systems at new compressor stations.

From this it can be seen that 6 to 30-in. valve operators are being used on plug valves and gate valves in automatic station emergency shut-off systems and manually tripped station emergency shut-off systems. They are being used in compressor stations and on the pipe line right-of-way for convenience, and in automatic systems for river crossing protection.

As valves become larger and larger and pressures higher and higher, the number of handwheel turns to close them, and the energy required to close them against the high pressure, is continually increasing. Table I shows clearly why large valves must be power-operated; the closing times are too long and too many personnel are required.

The necessity of valve operators is cogent and impelling in the light of an emergency, so that the next logical step has been to develop an integrated system of valve closure to isolate properties and pipe lines and equipment, thus protecting them from the ravage of fire and destruction, and at the same time save vast quantities of the salable product as in the case of main pipe line breaks.

The compressor station emergency shut-off system that is presented here is straightforward in design and basic principle, and full-scale field tests assure its performance. Many desirable factors are inherent in this system. For that reason it has been installed on the recent expansion of the Texas Eastern system of 465,000,000 cu ft per day to the market. This system or variations of it have been employed on 10 compressor stations.

This presentation of the design of the system is made to increase the general knowledge and to add to the literature on this important, yet not completely developed, phase of gas transmission operations.

Referring to Fig. 1, a compressor station emergency shut-off system functions to protect the station in times of emergency by closing the suction valve A and the discharge valve B of the station, and opening the station blow-down valve D to bleed off the gas in the sta-

The Author

Conrad William Marvin, chief of the plans and research section, engineering department, Texas Eastern Transmission Corporation, was born in Kansas City, Missouri. He received his education at the University of Kansas, receiving a BS degree in chemical engineering in 1942.

His first job was as an engineer with the U. S. Rubber Company. During World War II he served as an officer in the U. S. Air Force from April, 1943, to November, 1945, flying 36 missions in the Southwest Pacific. After the war Marvin worked as an engineer for Panhandle Eastern Pipe Line Company until May, 1947, at which time he joined Texas Eastern's engineering department.

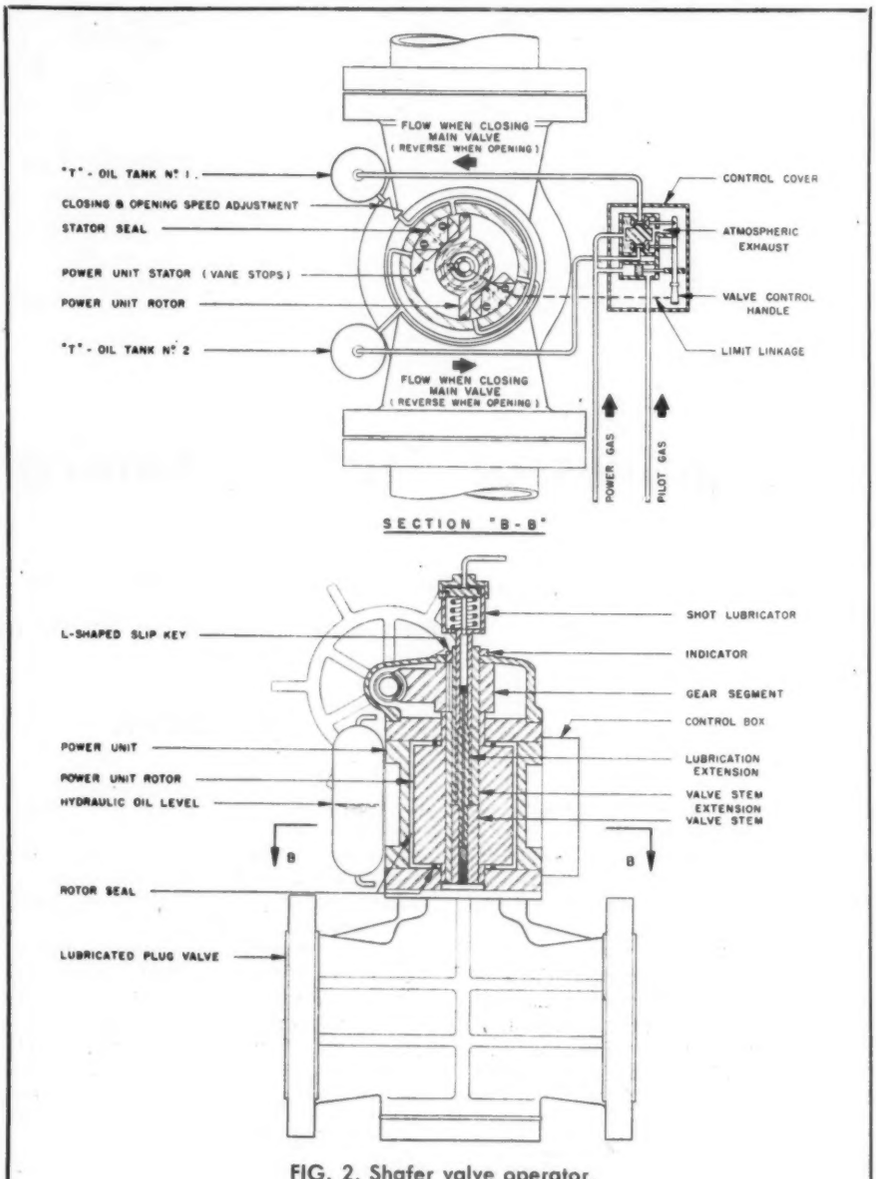


FIG. 2. Shafer valve operator.

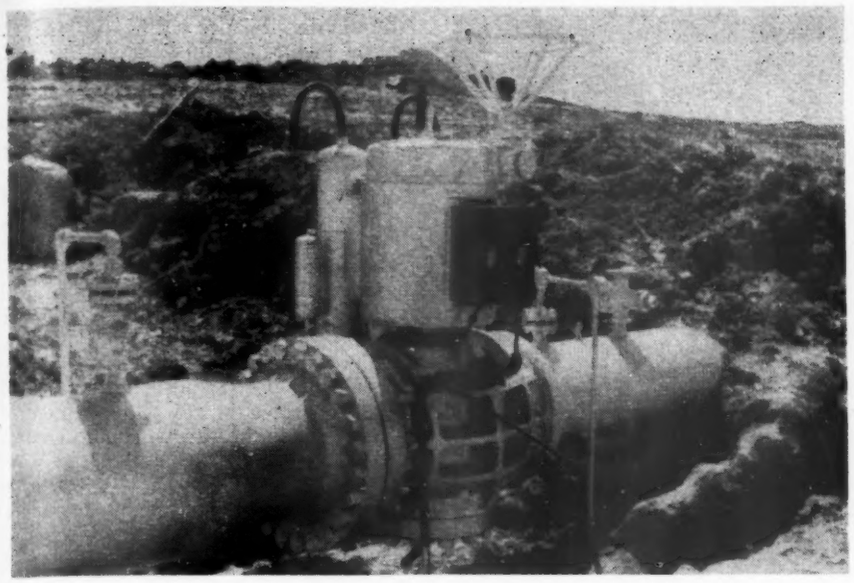


FIG. 3. Shafer operator on 20-in. Nordstrom plug.

tion proper. Fig. 1 is a generalized layout of a compressor station using this emergency system. The suction valve, the discharge valve, the bypass, and the station blow-down valve are plug valves installed with Shafer valve operators and controllers. The motive power used to work these operators is obtained from a power gas line (solid lines in Fig. 1) connected through the reservoir tank E to the main line. The reservoir is connected through appropriate piping to both sides of the station bypass valve C so that pressure will be available to operate the valves, even though the main line on one side of the station may have been bled down. The check valves F and G between the main line and the reservoir permit the gas to flow into the reservoir but will not permit it to flow back out into the main line. This insures that the highest discharge pressure will be trapped in the reservoir to serve the operators. A pilot gas line (dashed lines in Fig. 1), connecting to the suction, discharge, and blow-off operators to the reservoir through orifice H, can be bled down manually at valve J. The pilot line also can be blown down, using the electrical push button levers, opening solenoid valve S. The differential created by the orifice H and sensed by the Shafer instruments causes the Shafer operators to trip and activate the valves. Suction valves A and B close. Bypass valve C remains in its standard closed position. Blow-off valve D opens. The actuation of the valves is simultaneous. The main compressor units are automatically shut off. An automatic feature is incorporated at the station suction valve to blow down automatically the pilot gas line at K, and thus initiate emergency shut-off whenever the suction pressure falls at an abnormal emergency rate.

The system has considerable latitude and flexibility. Even though it is set for automatic emergency operation, the individual mainline valves may be operated with power using the control levers. Even though a man may be actually operating a valve in the opposing direction, if the emergency system is tripped, it will override the man on the lever. The man on the lever cannot oppose satisfactorily the automatic emergency forces that cause the valve to operate in the emergency closure.

Such features, and others in general, also permit simplified maintenance on this system without interrupting main compressor station performance.

The heart of the station emergency system is the valve operators. The Shafer operators selected for this installation were generally in line in cost with other operators for large-size valves and were less in cost for the 6-in. valves. A schematic drawing of the operator and its parts mounted in a plug valve is shown in Fig. 2. The valve is actuated by hydraulic pressure on the hydromotor vanes, which are integrally connected with the plug valve shaft.

The Shafer operator mounts directly on the plug valve platform flange (or on an extension for elevated gearing), and the valve gear housing mounts directly on top of the unit. It is a double vane, balanced torque unit with internal vane stops, quadrant overtravel stops, integrally mounted gas hydraulic tanks, piston actuated remote-manual controller, control box, and orifice controlled tank, including a lubrication extension stem fitting, hydraulic oil suitable for operation at atmospheric temperature of minus 20 F to plus 120 F, and all necessary piping, mounting bolts, and gaskets so that, mounted in the field with equipment installed, the valve is ready to operate when the pilot and power gas connections are made to the controller. The motor operator is steel bodied, ASA

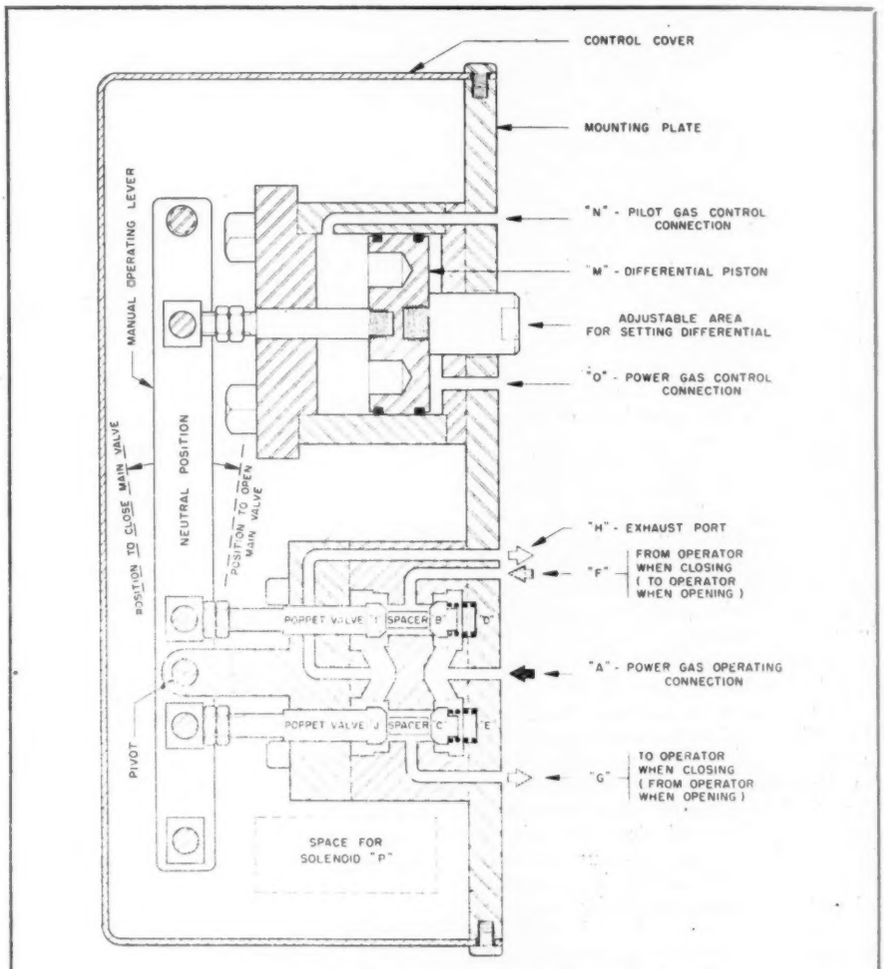

CONTROL COVER
MOUNTING PLATE
"N" - PILOT GAS CONTROL CONNECTION
"M" - DIFFERENTIAL PISTON
ADJUSTABLE AREA FOR SETTING DIFFERENTIAL
"O" - POWER GAS CONTROL CONNECTION
"H" - EXHAUST PORT
"F" FROM OPERATOR WHEN CLOSING (TO OPERATOR WHEN OPENING)
"A" - POWER GAS OPERATING CONNECTION
"G" TO OPERATOR WHEN CLOSING (FROM OPERATOR WHEN OPENING)
MANUAL OPERATING LEVER
POSITION TO CLOSE MAIN VALVE
NEUTRAL POSITION
POSITION TO OPEN MAIN VALVE
POPPET VALVE I
SPACER B
D
POPPET VALVE J
SPACER C
E
PIVOT
SPACE FOR SOLENOID "P"

FIG. 4. Controller for Shafer valve operator.

rated, and fitted with gage glasses. The exhaust is vented downward on the side of the valve opposite the control box. A picture of the operator on a 20-in. Nordstrom, ASA 600 plug valve at the Connellsville compressor station of the TETC system is shown in Fig. 3. An operator on a 6-in. blow-off valve also is pictured.

The controller is a fundamental part of the operator as used in this emergency system. A simplified diagram of the controller is shown in Fig. 4. This control consists of a cover and mounting plate to which are attached an ingenious four-way valve, a manual operating lever, and a differential control piston.

Fig. 4 shows the controller in the neutral position. In this position there is no pressure on the operator proper of any kind. Power gas at pressure is connected at point A and positively seats valves B and C, which are normally and firmly in place by virtue of springs D and E. Both ports F and G to and from the operator hydromotor are open to exhaust H through valves I and J. When the manual operating lever is pulled to "close main valve" position, poppet valve J is seated and the spacer lifts valve C from its seat admitting power gas through port G to operate the main valve closed. The swept volume from the opposite side of the hydromotor vane exhausts through port F from the hydromotor through valve I and out from the operator through port H. Fig. 2 shows how the controller feeds power gas to the hydromotor vanes through hydraulic tanks T.

The main valve is opened by pushing the manual operating lever L over to "open main valve" position, which unseats valve B, permitting high pressure gas to enter the opposite side of the hydromotor operator through port F, as valve I is forced closed when the lever is pushed in. The swept volume from the other side of the hydromotor in the opening operation exhausts through port G through open valve J and through port H to atmosphere.

Remote control by means of a pilot and power gas differential is accomplished with the auxiliary differential piston M. The pilot gas is connected at N and the power gas is connected to the other side of the piston at O. When the pilot gas line is blown down, the differential pressure set up across piston M throws the operating lever to the left, closing the main valve. Remote opening of the main valve could be accomplished by merely connecting the pilot and power gas on opposite sides of the same differential piston.

Certain salient features that make these Shafer valve operators particularly suited to emergency protection should be described here. The valve operator is fast with uniformly distributed turning torque that will close the valve as long as 150-psi gas pressure is available. Extensive tests have been conducted on the performance of the completed emergency system, and at 180-psi line pressure, all the 24- by 30-in. suction and discharge valves and the 6-in. blow-off valve at the stations were set for complete closure in 10 sec or less from the time the emergency station blowdown valves were opened.

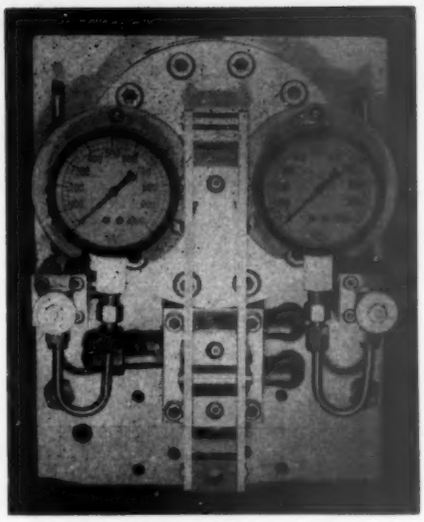


FIG. 5.

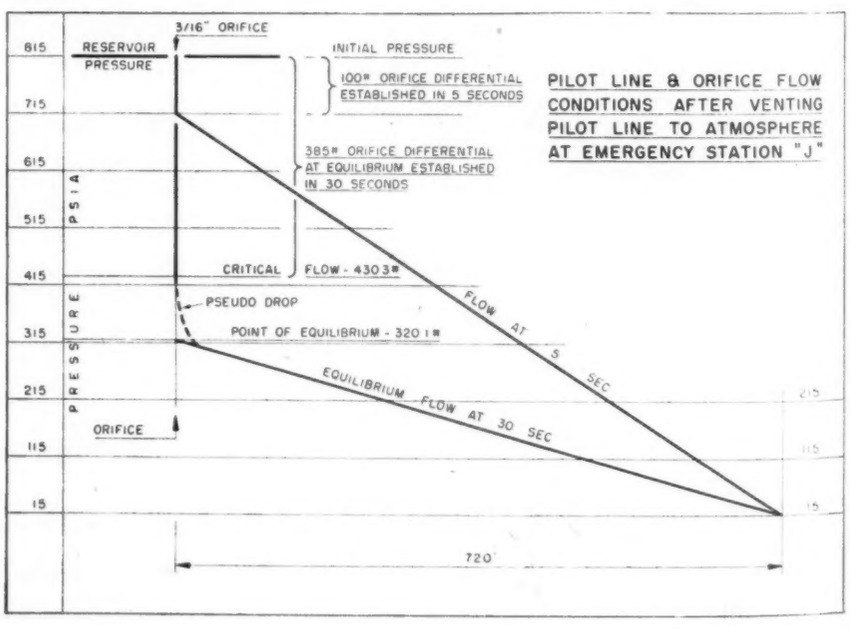
At 300 psi, line pressure closure time was 9 sec or less for all valves. Higher line pressures close the valves slightly faster.

Closures were made as rapidly as 5 sec without mechanical shock to valve. These tests were repeated at various stations and the results are deemed reliable and significant. The valve has adjustable closing or opening speed, which is controlled by a variable orifice valve in the oil circuit that is a snub adjustment to the operating time.

The volume and pressure of gas required to operate the valve are a minimum. It has a positive seal-off on the power gas, with a built-in bleed. Thus the valve will not creep in a dormant period. The controller can be set either to open or to close the valve. The valve is positive in emergency closing direction and non-reopening; or in the case of an opening valve, it is non-reclosing. The differential pressure setting of the differential piston is adjustable in the field, and it can compensate and adjust to the power and pilot gas line and orifice design. It has been noted that even though a man may be actually operating a valve in the emergency or an opposing direction, if the emergency system is tripped it will override the man on the lever L, Fig. 4. It is true also that regardless of what position the valve may be in, the remote differential piston control will cause the valve to function in a proper emergency direction. Space P can be utilized for installation of a solenoid, permitting electric push button control of the operator for any sequence control that is required, or any remote control that is required. The differential pressure piston can be designed to override this electrical solenoid if the emergency arises. The valve can be opened or closed without interfering with any of the other valves on the pilot system. The Shafer operator can be made to trip anywhere from 10 to 100 psi differential between the pilot line and the power gas line. The system design was taken for 50 psi. Other operators, however, are certainly suitable for this same emergency system and they are discussed in a later paragraph. The Shafer operator was employed on the TETC system, and because of familiarity with it, it was used by way of example.

The Shafer operators are shipped separately from the valve and are readily installed in the field. The plug valve is shipped complete for hand operation and the operator installed on it at any time or removed from it at any time, yet no alterations are required on the valve. By the use of a standard valve extension the valve can be buried, thus eliminating any valve box drainage problems. Lubrication of the buried valve is through the top of the operator. Hydraulic oil fills the system of the hydromotor, preventing rust. Any oxidation that may occur in the tank T is not serious.

FIG. 6.



The particular suction and discharge valves on the Texas Eastern system were installed in horizontal gas line aboveground with plug in upright vertical plane. Some of them on the bypass were mounted on an operator extension with gearing and handwheel mounted above the operator. The 6-in. Shafer operators are size 105D with auxiliaries indicated above; but they were mounted in the vertical gas line with a plug in a horizontal plane (See Fig. 14).

Returning from description of the operators to the station shut-off system, it is to be noted that one of the basic principles followed in the design of this shut-off system required that it operate directly. For this reason operators that could operate on line pressure were used. In this way regulators and related relief valves were eliminated with corresponding elimination of their maintenance and possible faulty operation.

Another of the main features of this system is that the entire power gas line is under continuous gas pressure so that gages can show the station personnel at all times whether or not the system is ready and capable of performing. Failure in the power gas line will drop the pressure. Thus, large leaks that would impair operation are detectable. Gages are visible at the operators, which are remote from the reservoir.

An equally important feature of this system is that the pilot gas line is continually under pressure. Severance of the pilot gas line would actuate the valves. Thus, they will fall into the emergency position. If welders cut into the pilot lines by mistake, or if the pilot lines are broken by a bulldozer, trucks or by any other yard work, the valve system will be activated, and it will not be left impotent.

A reservoir E, Fig. 1, is put in this system to guarantee under any circumstances that power gas and pilot gas will be available to perform the requisite operations.

A general description of the workings of the shut-off system has been given. Pertinent details of installation follow, and reference is to Fig. 1. The power gas supply to the reservoir is tapped off both sides of the station bypass valve. The usual basic mainline valve L is close to the mainline and underground. These taps are double valved with 1-in. valves M, which are sealed open with Tyden self-locking car seals and registered by the operating department. Check valves F are installed. A strainer O is installed with its blow-out valve P. This grouping of fittings is aboveground for accessibility and leads over to the buried reservoir tank, entering the tank at the top. A check valve Q is placed at the tank as final insurance in the event of rupture of the mainline in this area. To insure that no failure shall occur in the supply of gas, no other valves are placed between the mainline and the tank. If the tank is desired to be blown down the mainline double valves M may be shut off and the entire system bled down. Condensates drain toward the mainline from check valve F and toward the tank away from check valve F. Condensates are removed from the tank by blow-off R, which dips into the base of the tank. Mainline taps are 2 in., all other piping 1 in. except as noted. Power gas is taken off the top of the reservoir tank and leads in the nearest direct route to the various operators. All power lines from operators are laid to grade and drained into the reservoir. This insures positive freedom from freezing in the lines to the operators. It also eliminates sluggish operation from accumulated hydrocarbon liquids in the power lines at the operators. Strainers at operators on power line are periodically checked by blow-off. No valve or restriction is permitted in the power gas lines between the reservoir and the operators, other than the actual Shafer control itself. The pilot line is taken also from the top of the reservoir in a 2-in. tap and swedged to 1 in. at the orifice. This orifice union with changeable plate size for final adjustment and set is above ground. Liquids on one side drain back to the tank. The pilot line from the orifice is laid to grade and drains away from operators and orifice toward the blow-down emergency station J. Proper attention to drainage will prevent freezing; however, clogging or freezing of the orifice does not prevent the system from operating.

The pilot line leads from the orifice and operators to the emergency stations. The most remote of these stations, J, preferably placed in a naturally and easily accessible location with the compressor building between it and the major gas piping as a shield, is a manually operated 2-in. Nordstrom plug valve with operating wrench welded into place so it will always be available to the station personnel. This is mounted about chest high on a 2-in. blow-down stack that has the vent straight up and above the operator as he uses the handle. The stack, of course, is braced. More than one manual blow-down emergency station can be installed if desired. At another place away from the building, also placed so as not to cause fire when vented, and certainly not under electric power wiring, is a 2-in. Grove solenoid operated pilot line blow-down valve. This is a Grove regulator, Figure 882-352-BS, rated 1000 psi with screwed connection. Power is required to actuate this valve. This solenoid-operated valve may be actuated from push buttons T, Fig. 1, situated near doors or in convenient places within or outside the compressor building. In event of power failure only the hand-operated blow-down valve J could be used to actuate the system, except that automatic operation would be initiated by the automatic emergency station K as indicated later. A Mercoid switch DA-21-12S, 2000 psi mwp explosion-proofed, 200 psi to 1500 psi set pressure, is set in the pilot line to actuate and shut off the compressors whenever the power gas line is bled down. This switch, of course, is set at a suitable bleed down pressure, 300 psi or so depending on the station's normal operating pressure.

One of the most important factors about the system is that a station power failure (with subsequent knocking off the line of the entire station) will not upset the balance across the orifice inadvertently and undesirably. As the suction pressure would rise and the discharge pressure would fall, the check valve G between the discharge line and the reservoir would hold the gas in the reservoir and no differential would be created across the orifice H. Turning units on and raising the discharge pressure extremely rapidly will not operate this system inordinately either. A falling suction pressure has no effect on the pilot and power lines except the automatic emergency station, which is described later in the article. With a rising discharge pressure, gas is fed to the reservoir tank E, thence to the power line, and also from the reservoir tank E through orifice H to the pilot line. At the operator, gas from the pilot line is fed to the orifice control tank in the reverse direction from the activation requirement, consequently the operators and valves are unaffected.

Calculations were made to determine proper line sizes, reservoir size, orifice size, and line lengths. The conclusion reached from such studies dictated a 1-in. piping system, a reservoir 20 in. by 20 ft long, and an H orifice of a size of 3/16 in. Such orifice and piping have been proved by field testing to be of a size that well establishes the differential across the operators when the system is operated. The orifice and piping design give positive action to the operators and eliminates the mischance that the station valves can be left in the half-closed position. To accomplish this result an orifice was selected that reaches its critical flow state before the system comes into an equilibrium flow condition. The chart, Fig. 6, shows the design calculation of the differential established at the operator versus approximate time. The 100-psi differential required to activate these operators was calculated to be established in about 5 seconds. Field tests show that the operators commence action in less than that time. The blow-off valve began opening in 3 sec after tripping the emergency station. The 24-in. by 30-in. station suction and discharge valves are fully closed in 10 sec after tripping the emergency station. After the actuating differential is established, the differential continues to increase until such time as the rates supplied to the orifice becomes equal to that taken away by the discharge line. This is known as the point of equilibrium flow, and the system remains in this state until something is done to alter it. That state of flow was calculated to be reached in 30 sec, and actual tests confirm it. When the system is opened to atmosphere at the end of the pilot line, the line has to change from a static condition to a flowing condition before any differential can be felt at the operators. A differential begins to form from the gas escaping down the discharge line faster than it is being supplied through the orifice. Under normal conditions this entire system sits at a static pressure equal to discharge pressure, or at a higher pressure, depending on how recently the higher discharge pressure existed and on how much leakage occurs back through the

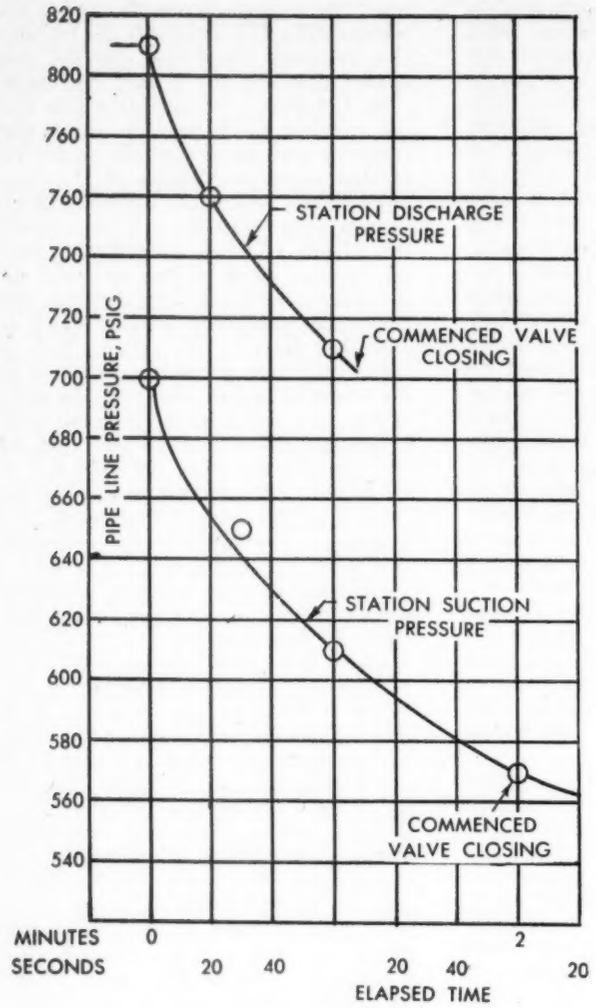


FIG. 7. PRESSURE CHARACTERISTIC—following break in compressor station 20-in. discharge line.

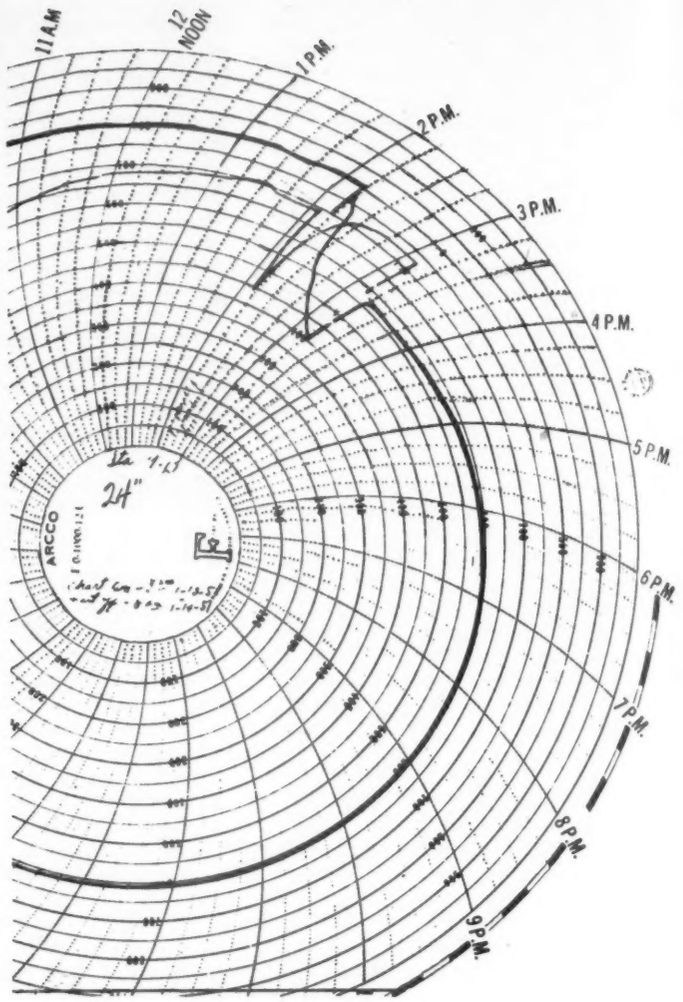


FIG. 8.

check valve between the reservoir and the mainline. All calculations were based on a condition resembling the most adverse disturbance that could take place, and experience has proved the basis to be adequate. Exhaust stack back pressure was checked from Bulletin E-40, 1939, of the American Meter Company entitled "Open Flow Capacity of Wells." A stack of 2 in. does not produce excessive back pressures.

The system described above depends on manual initiation of the shut-off cycle. This may be considered reasonably satisfactory, if station personnel can be depended upon to actuate the system in time of stress. If assurance is to be given that such an emergency actuation definitely will be initiated, however, some automatic device must be added. Description of the automatic emergency station follows.

The location of the station suction and discharge valves is such that they are a considerable distance from the compressor building proper. The basis of the automatic system is that, in the event of a complete line failure or other type blow-out in either the station suction line or in the station discharge line, the suction line will feel a drop in pres-

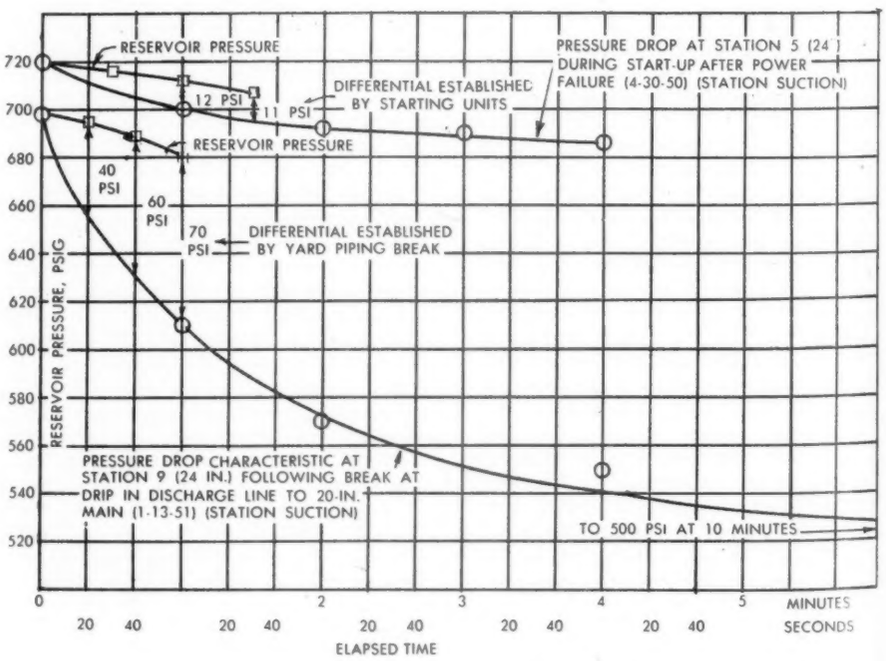


FIG. 9. PRESSURE-TIME CHARACTERISTIC—Bleeding down a 20-in. by 20-ft long reservoir through a ⅛-in. orifice into station yard piping following a local break and a station start-up of centrifugal compressor station.

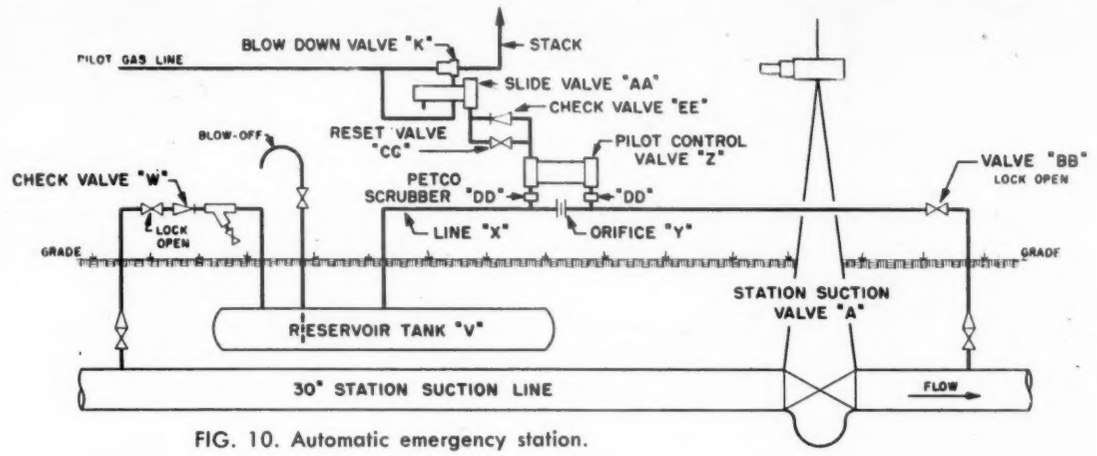


FIG. 10. Automatic emergency station.

sure. Obviously, if the line breaks in the suction, the suction pressure will drop there. If the line breaks in the station discharge piping, the unit bypass check valves of the centrifugal station will open and allow the suction to feed the break and hence suction pressure will drop. The station discharge check valve will hold the mainline discharge pressure back. In the case of a reciprocating station, the suction pressure of the station will drop with the discharge pressure if the engines keep running. Even if the engines stop the suction valve of the compressor cylinder will allow gas to come into the cylinder and the discharge valve will open when the discharge pressure lowers below the suction pressure, thus permitting flow through the compressors and the lowering of the suction line pressure, reflecting the drop in pressure of the blow-out.

Fig. 7 shows pressure characteristics at a station that was close to a mainline break. Note that the pressure fell on both the suction and discharge at a rate of approximately 50 psi per minute for the first 20 sec. Then the pressure fell approximately at a rate of 40 psi per minute for another 1½ min.

The original chart, from which Fig. 7 was drawn, is shown in Fig. 8. This chart registered suction pressure and discharge pressure outside the station emergency shut-off system. When the station valves closed the line pressure continued to register, of course. Note the slight and fleeting rise in discharge pressure upon closing the discharge valve. This is due to local disturbance with peak pressure being downstream from the station during the feed to the break.

The automatic reservoir tank V (Fig. 1) is connected across the suction valve A with check valve W allowing gas to flow into the tank from the mainline, and line X allowing gas to flow out of the tank to the mainline, keeping the tank at, and floating on, line suction pressure. The details of this tank are similar to previous ones in that the 2-in. connections are valved at the mainline underground. The 1-in. valves are locked open and the lines lead into the top of the tank. The tank blow-off, of course, reaches into the bottom to blow off the tank and the tank is somewhat canted to drain. The orifice Y will not create an activating differential with rising pressure because the check valve W will lie closed and only a reverse, non-activating differential could be set up. On a decrease in line pressure, however, the check valve W will close and flow will occur from the tank through the orifice to the mainline and create a differential. By the proper design of this orifice and the tank size a different magnitude of differential can be obtained suitable to distinguish whether units are just coming on the line in normal operation or whether there is a true line break within the station.

It is to be noted that if a leak of too small magnitude occurs the automatic system may not function, but such a leak would not be of sufficient severity to cause real damage or frighten the personnel to the point where they would not be able to throw the system manually. This automatic system is specifically designed to function in the case of an extreme break.

The differential across orifice Y is sensed by pilot control valve Z. This is a Grove valve type M. (See detail of connection of pilot control valve, slide valve, and valve K in Figs. 10 and 11.) When pilot control valve Z actuates, gas is fed to slide valve AA, throwing it to open the relief valve K. This bleeds down the pilot line of Fig. 1 much as do the manually controlled bleed down valves. With reset valve CC closed (see Fig. 11), check valve EE is a trigger on the slide valve AA that keeps the slide valve in actuated position and valve K open, regardless. This is a very simple and direct system. After the pilot line system is actuated, the 6-in. blow-off line on the main discharge line opens and increases the positiveness of the pressure drop on the suction side of the

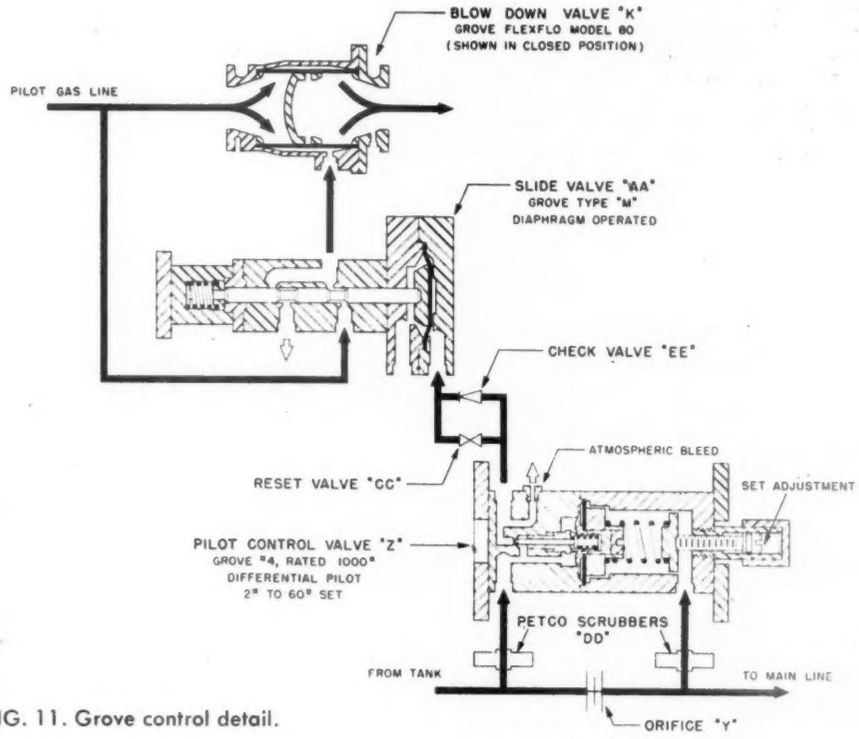


FIG. 11. Grove control detail.

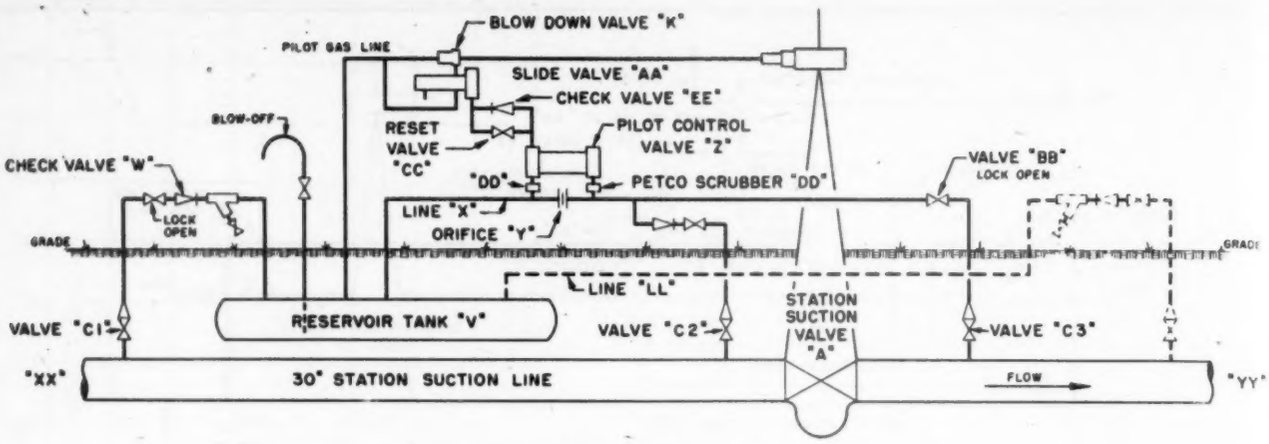


FIG. 12. Automatic main line valve closing system.

line, thus tending to maintain the differential across Y. This is particularly true when valve A begins to close, after which gas continually flows across orifice Y from the high side of the valve to the low side. It is noted that under these conditions some gas is being fed at all times across Y into the broken side of the line, but this quantity of gas is relatively small and will not do damage. As soon as the main valves of the system have closed off, closure of valve BB will stop feeding the faulted area. When BB is closed, pilot valve Z equalizes, and then temporarily opening reset valve CC closes valve K resetting the pilot line, at which time the emergency system of the entire station is ready to function again. Pilot valve Z is a snap acting valve and will not cause throttling through the pilot line. Bleed to the break could be eliminated by closing BB with a cam device from valve A.

Drainage from the orifice Y is toward the line and from the orifice toward the tank. Pilot valve Z is installed in a horizontal position to effect drainage from its taps. Such attention to drainage will prevent freeze-up of condensates and there will be very little liquid to be moved out into the mainline if any is condensed between the orifice and valve BB. The blow-down valve K, slide valve AA, and pilot control valve Z, have been designed to be supplied and installed as an instrument unit.

Even if a reverse differential did occur across the orifice Y it would not trip the pilot line. This means that, in the event of a power failure, the suction pressure rising sharply would not cause the system to actuate.

Calculation of the drop rate in the mainline, which would cause actuation, is simple and forthright. It depends entirely on the nature of the orifice Y, the lines to the tank from the mainline, and the tank. The units have been field set for 60 psi differential on the pilot valve orifice Y, that has a set range from 0 to 100 psi.

The system used in detecting a line drop in pressure across the suction valve has two useful variations. The Shafer operator requires very little capacity and the orifices of the control can be small, but when operators are used, such as centrifugal vane operators on gate valves where a great number of turns are required or a larger capacity may be required to actuate the valve, the following application of the system using a Grove controller is suitable. (See Fig. 13.) The power line and pilot gas line are brought to the operator just as in the case of the Shafer operator. The usual four-way valve leading the power gas to the operator is spring loaded to the emergency position. Flexflo valve K is put in the power line to choke off power gas from the operator. In this case also, as in the Shafer case, the operator is not under pressure except when operating. Slide valve AA and pilot valve Z are in the system. Pilot valve Z is connected across the power and pilot lines. Pilot valve Z is set for the differential desired between the power and pilot to initiate the valve action. This particular grouping is suitable for the actuation of any type valve operator by a differential pilot and power gas as used in this system. Where capacity is not large Flexflo valve K can be eliminated, running the power gas through valve AA to the operator.

The second use of this special system is adapted to a problem that is being reviewed by many people in the gas industry at this time. That is an automatic mainline valve closing system. (Fig. 12). This system employs the emergency reservoir tank V. This tank is connected to the mainline at C-1, C-2 and C-3 through double valves, checks, and strainers. The orifice Y is in the line X. Orifice Y reacts on pilot valve Z. Pilot Z reacts on slide valve AA, slide valve AA opens Flexflo valve K to feed the operator, which has its directional valve set and spring loaded for closing position. In the event of a mainline break at XX, differential is set up across Y

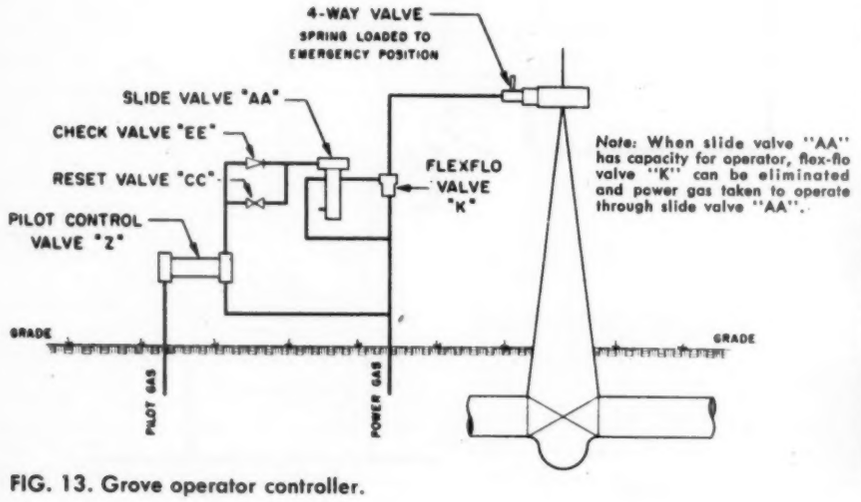

4-WAY VALVE
SPRING LOADED TO EMERGENCY POSITION
SLIDE VALVE "AA"
CHECK VALVE "EE"
RESET VALVE "CC"
PILOT CONTROL VALVE "Z"
FLEXFLO VALVE "K"
Note: When slide valve "AA" has capacity for operator, flex-flo valve "K" can be eliminated and power gas taken to operate through slide valve "AA".
GRADE
GRADE
PILOT GAS
POWER GAS

FIG. 13. Grove operator controller.

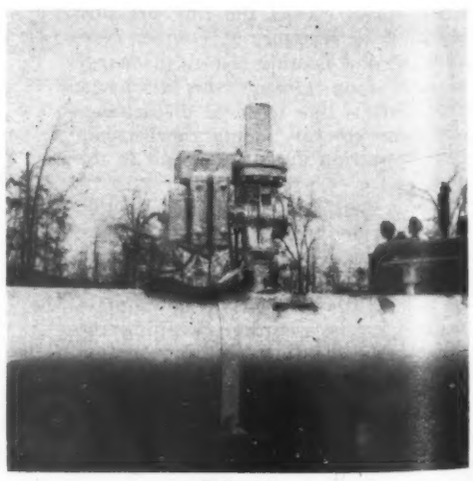
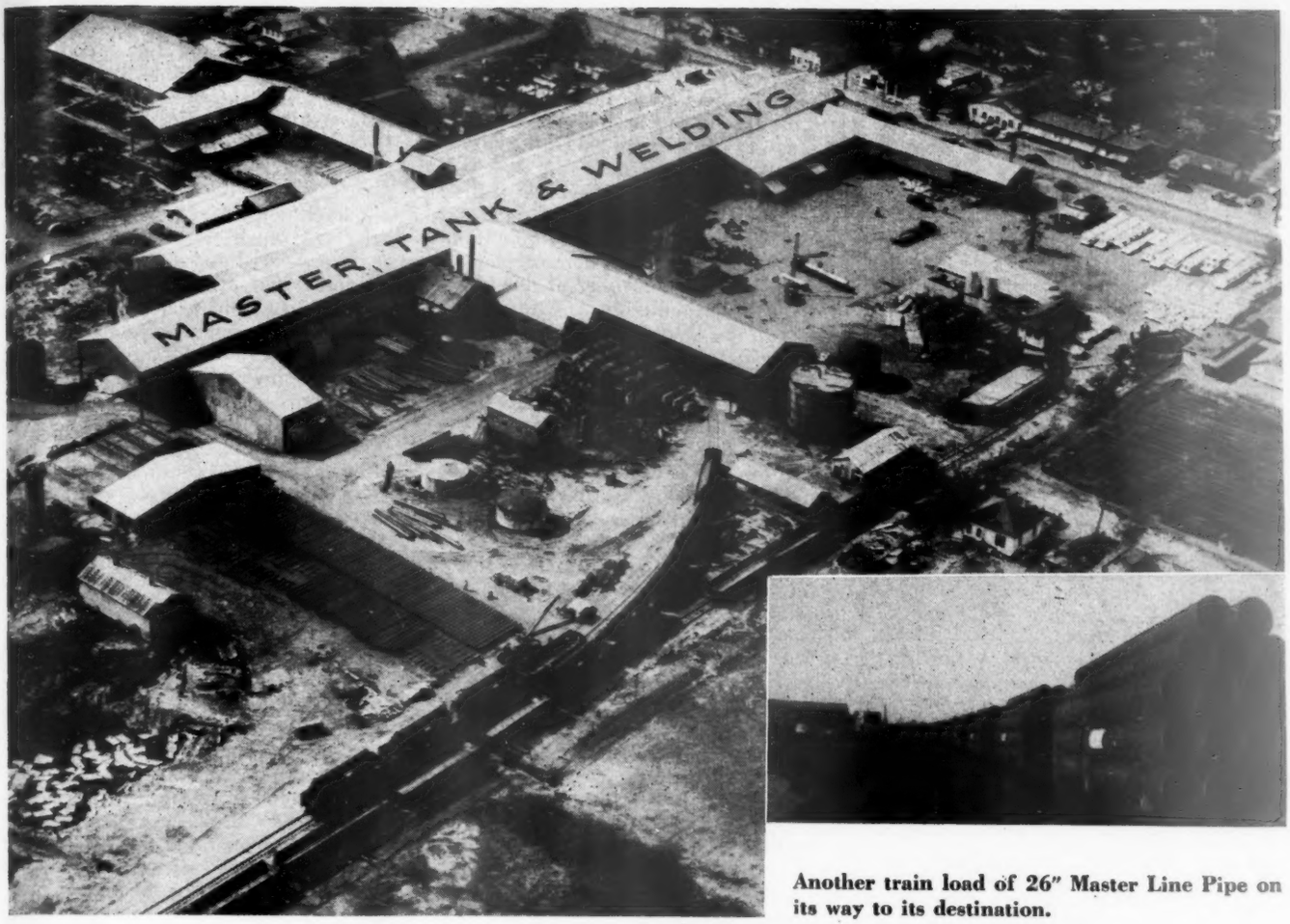


FIG. 14.



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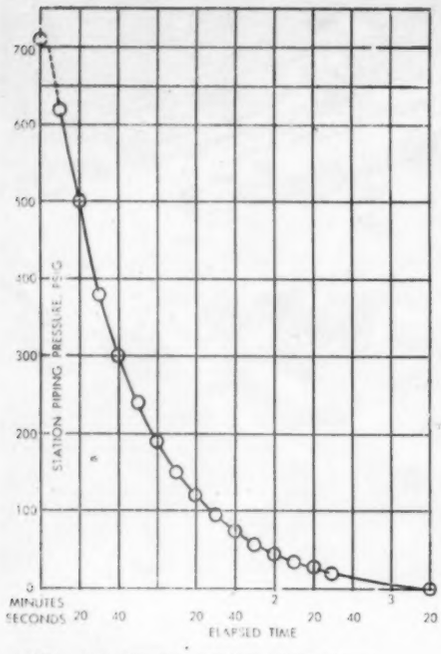

FIG. 15. Barton station blow-down.

Note: "0" minutes and "0" seconds represents time station emergency shut-off system switch was pulled.

and the valve closes. In the event of a break at YY, differential is set up at Y and the valve closes. Line LL can be added to the system is it is desired, in the case of an upstream break, to replenish reservoir V from the downstream side. In such cases, reservoir V would not have to be quite so large for a guaranteed operation.

This system is mentioned here but the use of it on the mainline could be extended into a lengthy discussion because of the varying rates of pressure drop depending on length and location of the break relative to the valve. At best, the assignation of a particular pressure differential to set up in the case of a mainline break is very complex and needs considerable consideration relative to normal operating techniques of the compressor station.

It is conceivable that such a mainline valve could operate when not desired and cause an entire pipe line of valve safe systems to shut itself off the line. For river crossing work, however, where breaks are immediate and close to a valve this system seems to be very apropos and permits use of other operators than conventional piston plug operators.

Tests were conducted at the various compressor stations where the emergency shut-off system was installed to determine the rate of gas blow-down at the station. A typical blow-down curve at one of the centrifugal compressor stations, Barton, Alabama, is shown in Fig. 15. It is interesting to note that the pressure was reduced by half in the first 30 sec after tripping the emergency station blow-down valve. All points shown are test data. The station piping that was blown down consisted of 2940 cu ft of 30, 24, and 20-in. pipe, including the scrubbers. The logarithm of the station piping pressure (psig) plots as a straight line against time. Other data at other compressor stations graph also as a straight line on such a semi-log plot, but the slope of the line varies depending on the volume of the station piping to be blown down. It is noteworthy that at the Barton station, blowing down the gas from 900 psi to 600 psi requires but 20 sec.

Returning again to the basic station emergency shut-off system, it has a real advantage in its flexibility of operation. Any one valve of the system can be operated from the controller of that valve without influencing any of the other valves in the system. Because of the overriding nature of the differential pressure on the controller, if an emergency occurs when the valve is in a half-closed position, or any position, the valve will proceed to the emergency position directed for that valve, as soon as the operator actually working the valve turns loose of the control lever. If the valve is already in the emergency closed position, then it would merely remain there if the emergency occurs. Under none of conditions will this particular valve influence any of the other operating valves on the system.

This is a feature not common to systems that require the piping to be pressured to all valves at the same time; thus, operating one would operate all unless shut-off valves were installed in the emergency power lines, which shut-off valves would continually constitute a hazard if accidentally closed.

This particular characteristic of the system lends itself admirably to periodic testing of the equipment. Either the system as a whole can be tested by bleeding down the pilot line or the manual control lever can be thrown to actuate each individual valve to show that it is operative. Periodic testing should be just enough to show that the valve will close, and this can be done by initiating partial closure, thus not interrupting service. Less frequently the entire system should be shut in to test the function of the controls, which are quite rugged. During these periodic testings the tank should be blown down occasionally, which will not affect the system, and the various strainer valves should be opened and residues blown from them. The time of operation under the particular pressure conditions will indicate whether or not the orifice needs to be checked.

Obviously, any of the particular valves can be operated by remote control if flow conditions warrant such. Of course, periodic inspection is to be made on the check valves in the control proper, the nylon balls, seats, and in the case of the slide valve and the pilot valve an inspection of the diaphragms and O rings can be made. The operator is readily and quickly converted from power to manual operation without removing the operator.

It may be commented that when a manual blow-down is executed on the pilot line, equilibrium flow will be experienced through the orifice and the pilot line and until the pilot line is shut off gas will escape at that stack. Shutting off this blow-down valve will cause the pilot line to repressure and the system is again set for automatic emergency operation and for operation of the valves with operators. Blowing down the pilot line with the solenoid-operated Grove valve will cause gas to escape from its stack so long as power keeps the solenoid open. A re-set button can close that valve in the same manner that a manual control can close the manual valves. At such time the pilot line is again pressured and the system is ready for individual operation of the valves for emergency operation. In the case of the automatic emergency, operation at the suction valve, closing of the valve BB and temporarily opening valve CC, will again set the system to pressure the pilot line and put it in readiness for emergency or individual valve operation through operators. In all of these re-settings, however, the valves will remain closed, or in the position required by the emergency operation, until such time as an individual manually operates the controller to return the valve to its normal operating position.

The station bypass function comes under considerable fire pro and con, but it is the writer's opinon that the bypass function should be excluded from the emergency system and be delayed in function. In regard to this, it is adduced that the primary function of the emergency system is discharged when the suction and discharge valves close. Though it is desirable and convenient to have the bypass valve open automatically, unless it can be done so without hazard the bypass valve should not open automatically. Against the ease of automatic bypass opening is the potential danger of a pipe line break on the discharge line outside but close to the station discharge valve.

It is manifest that these emergency shut-off or control systems perform a very definite function and real benefits have been derived from them from time to time. When a disastrous fire is prevented these systems are lauded, but when they have to be maintained we are prone to use various forms of invective. Nevertheless, as the system must function in the event of emergency, it must be maintained properly at all times. Sufficient testing must be provided to insure that the system is always in functioning order, and personnel must be familiar with every detail of the system.

Automatic emergency shut-off systems provide a means of immediate positive control. They can save gas. They can prevent great damage from fires. They can save life. A compressor station emergency shut-off system is, perhaps, one of the most positive protective features that can be obtained in the gas transportation industry. And for so little cost! The need of them is quite evident to anyone who has been responsible for the safe and continuous operation of a transportation pipe line.

The system presented herein has been designed on a basis of positive, sure operation. Every consideration has been in that direction. It is set up to operate speedily, and provide easy inspection and maintenance. ★ ★ ★

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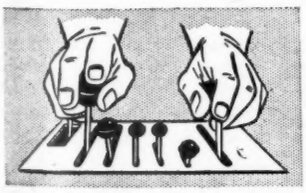

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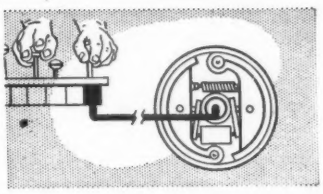

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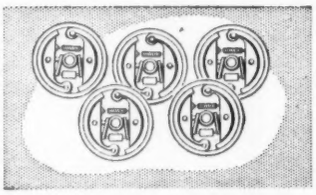

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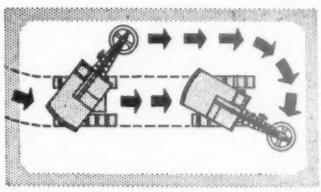

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Trench hoes digging Bow River near Banff. Depth of water was 4 ft 6 in. at this spot. P 623.

Canadian Project Replete With Obstacles

Calgary-Banff gas system was laid over erratic terrain and, under lakes and rivers during sub-zero weather

HARRY CHAPIN PLUMMER

Tractor mounted bending shoe bending 8-in. pipe.

IN the construction of approximately 80 miles of pipe line from Calgary to the Jumping Pound field, to Exshaw, and from the latter point to Banff, Alberta, Canadian Western Natural Gas Company, Ltd., of Calgary, the builders, encountered all the obstacles that could be anticipated and some unanticipated. They stemmed from the plummeting of winter temperatures, from the erratic contrasts of terrain contour and composition, and the problems occasioned by rivers and lakes. Hot springs feeding one of the latter melted the 2-ft ice and caused a break-through of machinery, which an ice-thickness probe, borrowed from the University of Alberta, located and brought about recovery thereof.

In one instance the route underlay the famed Banff Springs Golf Course, but hand labor, plus extreme care, left tree growth and landscaping undisturbed. In another it worked beneath an Indian reservation, which, however, proved to be a "blessing in disguise," for the Morley tribe, being excellent woodsmen, exercised more than ordinary caution in burning the slash and so avoided fire risks on their land. In yet another it

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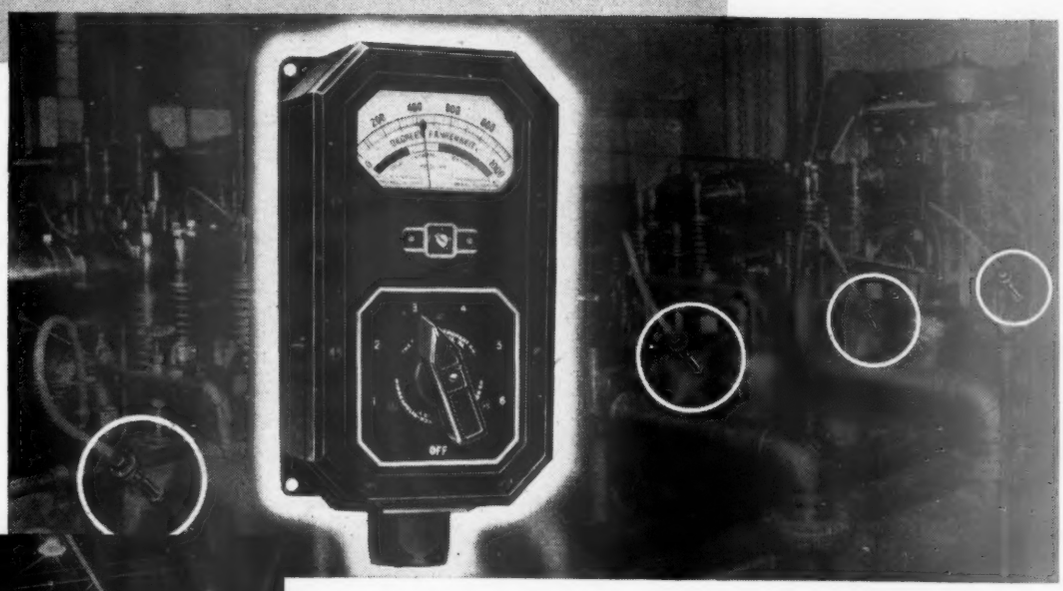

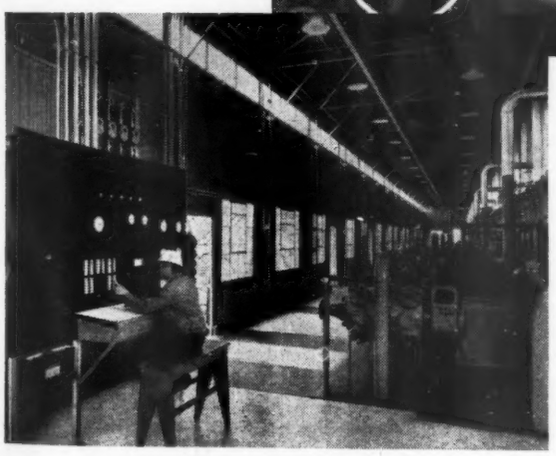

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Installing river crossing at Elbow River near Calgary.

paralleled for several miles the Canadian Pacific Railway right-of-way with its heavy transcontinental freight and passenger traffic.

Canadian Western Natural Gas Company, Ltd., distributes natural gas in southern Alberta. Recently a new gas field, the Jumping Pound field, was developed by Shell Oil Company of Canada, Ltd., and Canadian Western built the pipe line that extends to Banff.

The system is in four divisions: (1) Calgary to Jumping Pound field, (2) Jumping Pound field installations, (3) Jumping Pound to Exshaw, and (4) Exshaw to Banff.

The section from Calgary to Jumping Pound is 27.4 miles long, and is of 12¾-in. OD pipe. Although originally scheduled to be constructed in the summer and autumn of 1950, various shipping delays postponed start on the line until October 21, at which time days are short and extremely cold weather imminent. At the beginning weather conditions were ideal but near completion a bad weather spell occurred in which temperatures dropped to minus 40 F.

Due to the late start, pipe was unloaded and strung directly from flat cars. The area traversed by the pipe line is not well served by railways, and the pipe hauls were fairly long. Welding was begun as soon as the first pipe was strung.

Coating and wrapping 12-in. pipe near Jumping Pound.

and continued without interruption. Pipe came in random 40-ft lengths, and was of seamless Grade C steel, mill tested to 1500 psi for a working pressure of 1200 psi. Manufactured in England, it was transported to Vancouver by ship and to Calgary by rail.

Work began south of Calgary where the line joins Canadian Western's existing pipe line system, and ended at the Shell gas plant. Pipe ends were preheated to approximately 100 F, and in cool weather the welds were not allowed to cool until completed, when they cooled slowly after being wrapped with asbestos felt. This prevented weld cracks. Welding was radiographically examined throughout.

The line was coated with hot enamel, and wrapped with asbestos felt. A minimum cover of 32 in. was usual. The pipe was bent to fit the ground. The right-of-way was 30 ft wide, with the line 10 ft from one boundary, and crosses rolling foothill country with rock outcroppings on the crests of the hills.

Near Calgary the Elbow River was crossed, having a width of about 250 ft and a maximum depth of 17 ft. Regular line pipe weighted with concrete river weights was used. On completion, the line was cleaned with a scraper before being tested. The stand-up test was 750 psi and a leakage test was made at a pressure of 200 psi with a gage left on for several days until a state of equilibrium was reached.

Jumping Pound Installations

In the Jumping Pound field, the Shell Oil Company of Canada has a scrubbing plant operating at a pressure of 800 psi. Gas is delivered to Canadian Western at that pressure at a small regulator station. The station has a back pressure regulator set at 500 psi. The transmission line to Banff receives gas up to its required load at 500 psi and any excess gas that would tend to build pressure higher spills through the regulator into the line leading to Calgary. The Banff line and the Calgary line are connected through a check valve, so that if the Banff line pressure drops below 500 psi gas flow reverses in the line to Calgary and flows to Banff. A pressure of 480 psi is maintained on the line to Calgary.

From the regulator station, both Banff and Calgary lines pass through an orifice meter station. In addition to the recorders in that station, there are four telemeters that transmit the readings of the static pressure and the differential pressure on each of two orifice meters, one for Calgary and one for Banff. These readings are received at the Calgary high pressure station, and line conditions are under the supervision of the operators at all times.

At this time it should be mentioned that the terminal pressure at the Calgary end of the western system is also telemetered to the station operators.

Jumping Pound to Banff

From Jumping Pound westward to Exshaw, the pipe line is 8⅝-in. OD Grade B, 29.1 miles long. This section is designed for a maximum working pres-

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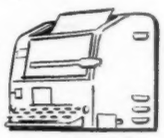

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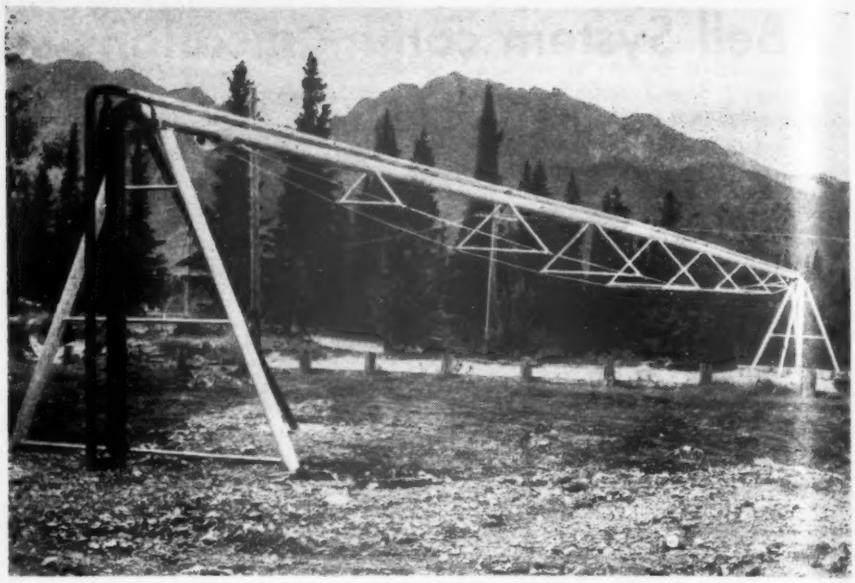
sure of 800 psi. It traverses foothills, a series of valleys separated by rock ridges, for the first 7 miles. The country is devoted to ranching. The Morley Indian reservation straddles the route. After the first 7 miles, the line descends a steep long hill to the Bow River gravel flats, which it follows for 15 miles to Seebe. At Seebe the pipe crosses a power canal and the Bow River, and leaves the Indian reservation. After about a mile, the line joins the right-of-way of the Canadian Pacific Railway and follows that route to Exshaw, ending opposite the plant of the Canada Cement Company, which is the main load served by the pipe line.

Construction on this section was begun as early as possible in the spring of 1951, about April 15. The frost was not entirely out of the ground at that time, so the Morley gravel flats section was completed first. To break up the gravel bed to allow the ditchers to operate a ripper was pulled along the ditch line.

To clear away the brush on the right-of-way, Indians from the reservation were employed as they are excellent woodsmen. Working on their own land, they were careful in burning the slash not to allow any fire to get out of hand.

For April and May ideal weather was the rule, but in June continuous heavy rain slowed all operations virtually to a standstill. The country between Jumping Pound and Morley has no gravel roads, and the existing trails were soon impassable. Estimated completion date was July 1, but the line was not completed until July 20. Aside from the extremely rainy June, no unusual difficulties were encountered on that section.



Crossing of power canal at Seebe. Span of 150 ft carried 4-in. atop 8-in. pipe.

From Exshaw the pipe line is 6⅝-in. OD, Grade A, working pressure 800 psi, and 22 miles long. With only a few exceptions, the line is on the CPR right-of-way to within 5 miles of Banff.

The line crosses several lakes and swamps, and three rivers, the Cascade, the Spray, and the Bow. Under the lakes, the line was weighted with junk 10-in. pipe. Under the rivers the 6-in. pipe is entirely inside a 10-in. casing, which allowed rock backfill to be placed without damage to the pipe coating.

The line across the lakes was installed in wintertime, with crews working on ice 2-ft thick. Unfortunately there were hot springs in some of the lakes, causing thin sections in the ice. After some of the machinery broke through, an ice thickness probe was borrowed from the University of Alberta to locate these sections.

Near Banff the line was installed across the Banff Springs Golf Course. This work was done nearly entirely by hand labor, and damage was held to a minimum. Landscaping and trees were preserved in their natural setting. Everywhere in the National Park area, the cutting of trees was kept to a minimum.

The final completion of the line was followed by a stand-up test of 750 psi. In the year following construction, there have been but three leaks. Two developed from small dents in the pipe, which produced minute splits. The third was found recently, but only because it was under water. It has not yet been possible to lower the water for repair.

On the line to Calgary, two drips of the company's own design have been installed for removal of any water, gasoline, or fluid. There is a similar drip on the line to Banff.

The meter recorder piping and the telemeter transmitter piping runs are protected by condensate traps, and the orifice fittings are provided with blow-offs. These traps have caught a small amount of gasoline occasionally. Aside from this, operations have been virtually trouble free, which is attributed to the large amount of slack built into the lines and to the procedure of running scrapers not once but several times in an attempt to obtain as clean a line as possible. It is the expectations of company management that after all such tiny leaks have been found and repaired, the operating problems will be minor, and will consist largely in servicing valves and repairing any erosion to the right-of-way. * * *

There's nothing like a VOSS VALVE

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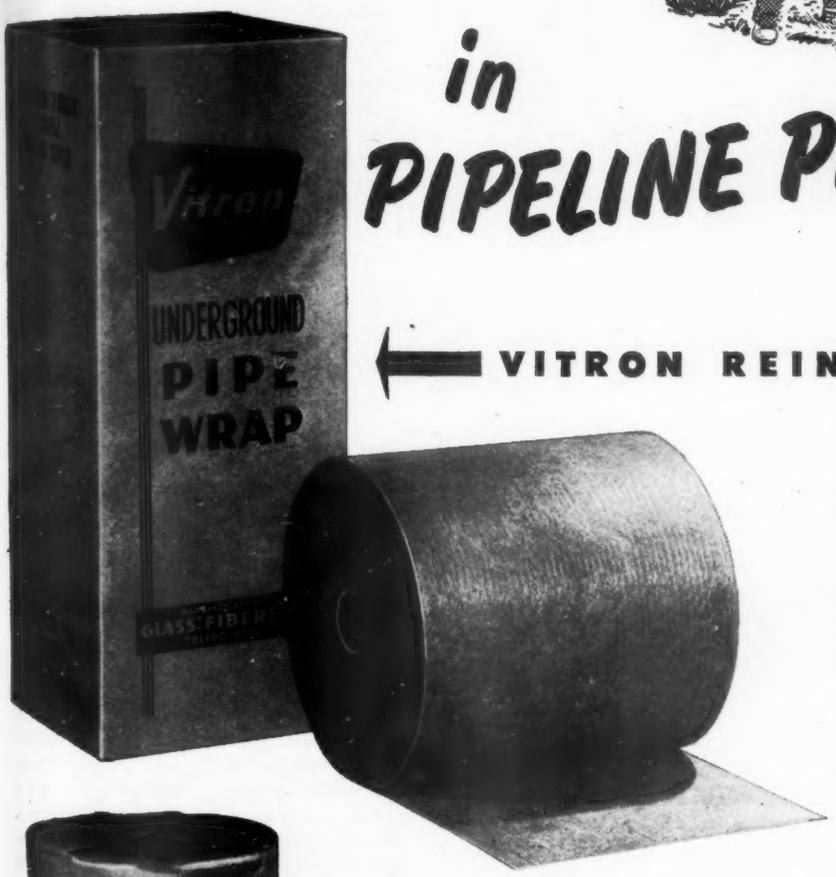

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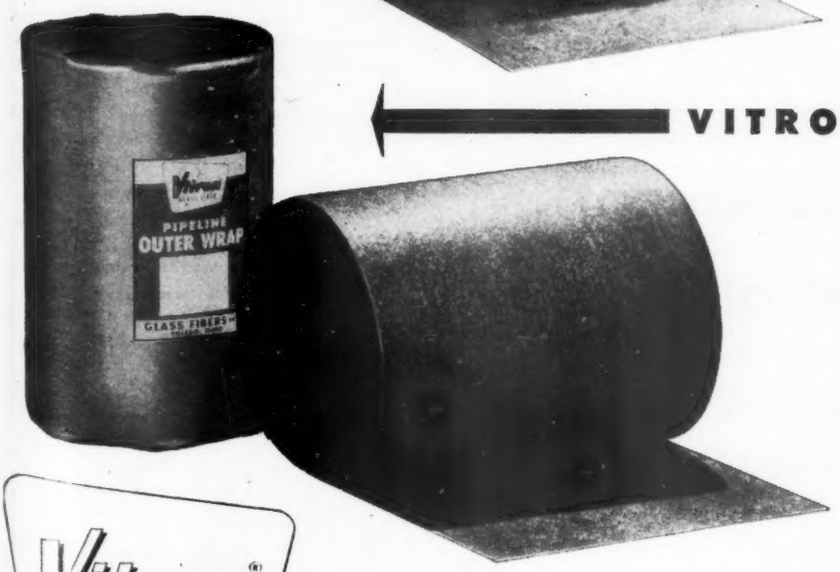
Vitron Reinforcing Wrap pulls in fast and taut, allows coating to bleed through uniformly, breaks up holiday-forming gas bubbles and holds the enamel firmly in place. Composed of glass fibers in mat form, reinforced with strong parallel glass yarns, Vitron Reinforcing Wrap is applied at high speed in over-the-ditch or yard operations.



VITRON OUTER WRAP

Vitron Outer Wrap cushions pipelines during lowering-in, protects against backfill and gives added resistance to soil stress. It's made from an asphalt and tar compound, reinforced with glass fiber mat and yarn. It anchors firmly to coatings, yet allows trapped gasses to escape through minute pores. For information on how these partners can protect your pipelines, write Glass Fibers Inc., 1810 Madison Avenue, Toledo 2, Ohio.

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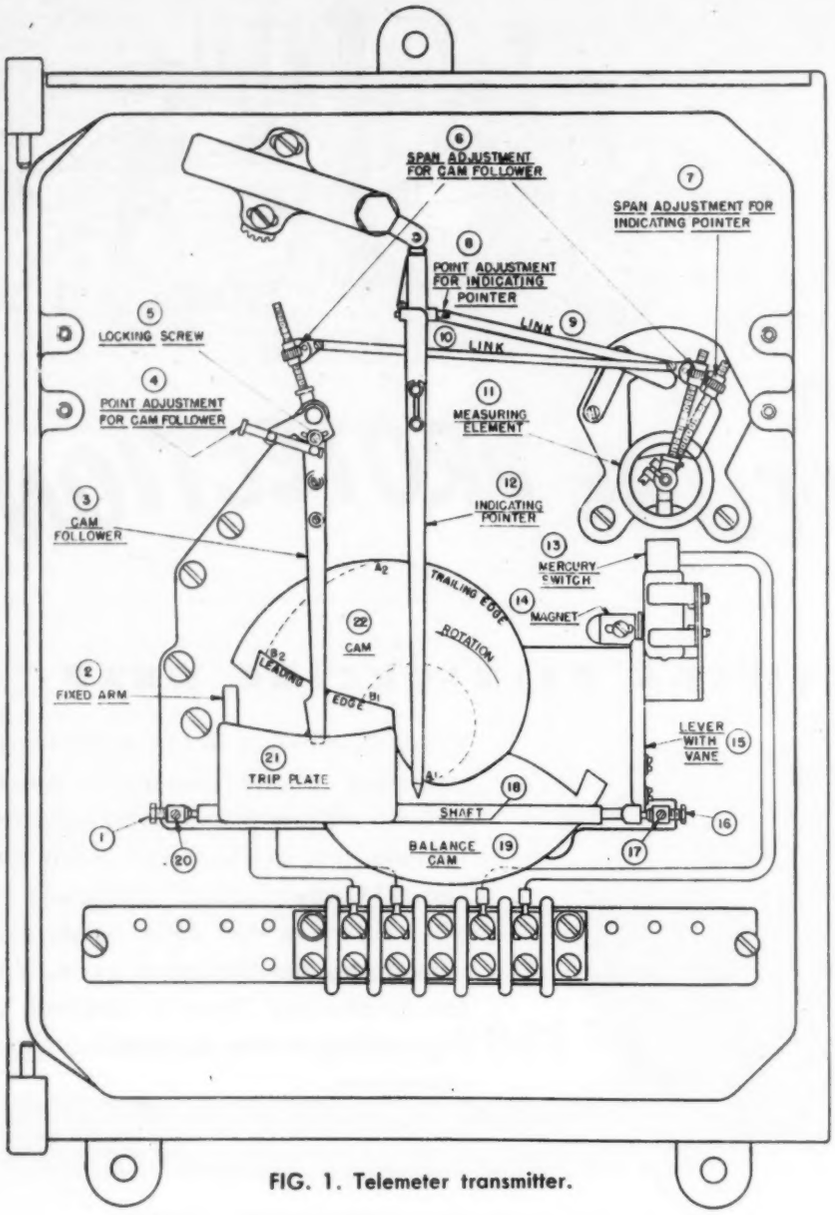


FIG. 1. Telemeter transmitter.

Remote Measurement and Control

Operations simplified and made more efficient by centralizing readings and providing finger-tip control

WALTER E. RUFLETH

"REMOTE measurement and control" is a term being used more commonly every day, particularly in the gas industry. It is no longer necessary to travel to various points of a gas distribution system, nor to have men stationed at remote locations, in order to make measurements or carry out the necessary control operations. Telemetering can do a very efficient job of this, bringing measurements and control functions from remote points to central dispatch locations. Here the dispatcher has before him the complete picture of conditions existing throughout the system, and has at his fingertips means for making any necessary changes in gas flow or pressure anywhere in the system.

Telemetering

Telemetering is the reproducing, at a convenient location, measurements made at a remote point.

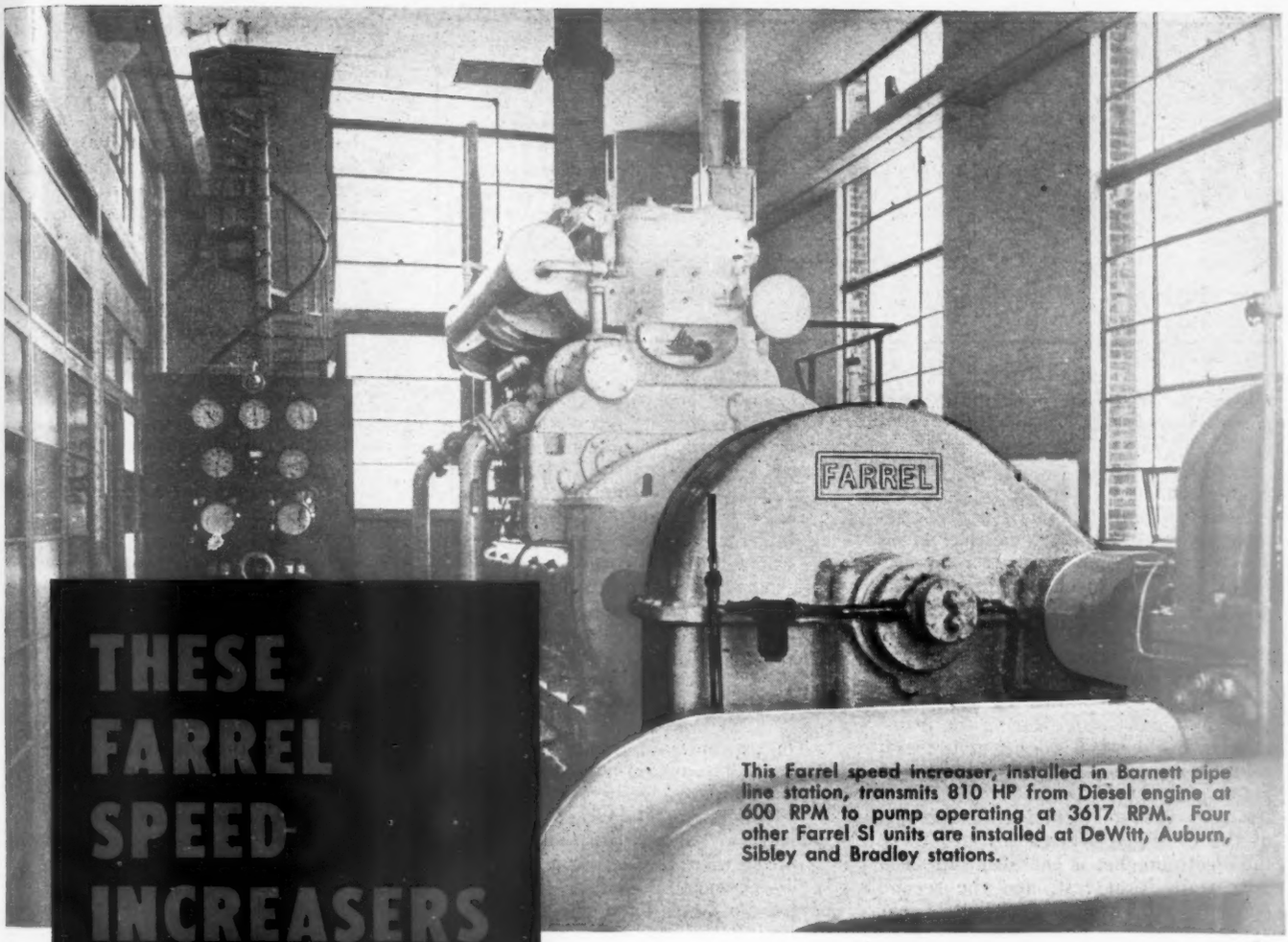
For simplicity of understanding, let us divide a telemeter system into three units: (1) Transmitter, (2) receiver, and (3) a transmission circuit. The transmitter measures the quantity involved, such as static pressure, differential pressure, or temperature, and converts it to an electrical signal. The receiver uses the electrical signal to actuate a pen in the case of a recording receiver, or a pointer of an indicating receiver. The transmission circuit connects the transmitter to the receiver.

Fig. 1 shows a telemeter transmitter for measuring and transmitting static pressure. The measuring element (11), in this case a bourdon spring for measuring pressure, positions cam follower (3), which rides on the surface of cam (22). Cam (22) is rotated by a constant-speed motor. Cam (19), mounted on the same shaft but to the rear of cam (22), is only for mechanical balance. When cam follower (3) rests on the surface of cam (22), trip-plate (21) is positioned so as to hold metallic vane on lever (15) out from between permanent magnet (14) and mercury switch (13). This opens switch. As cam rotates, cam follower drops off cam, allowing vane to pass between magnet and switch, thereby closing switch. At zero pressure, angular position of cam is such that its tip describes a path shown by dotted circle A_1B_1. At maximum pressure cam follower rides on cam from A_2 to B_2. Therefore, at zero pressure, switch is closed for a shorter period of time than at maximum pressure. For example, with a 5-sec cam cycle (the time it takes for cam to move one revolution), switch (13) is closed for one second when pressure is zero, and four seconds when pressure is at

The Author

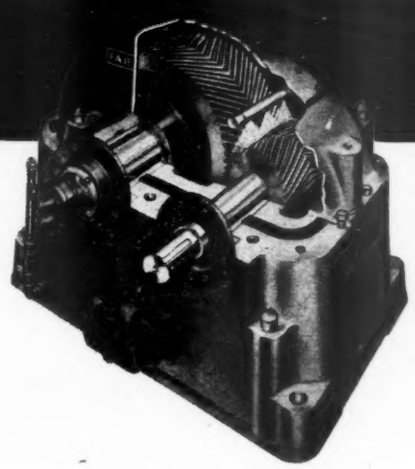
Walter E. Rufleth, application engineer with The Bristol Company, Waterbury, Connecticut, has an electrical engineering degree from Rensselaer Polytechnic Institute and is a registered professional engineer in the state of Connecticut. Since 1935 he has been associated with The Bristol Company in various capacities as product and development engineer. At the present time he is connected with the application engineering department, responsible for the application and use of telemetering, remote control equipment, and electrical measuring instruments.

EXCLUSIVE



This Farrel speed increaser, installed in Barnett pipe line station, transmits 810 HP from Diesel engine at 600 RPM to pump operating at 3617 RPM. Four other Farrel SI units are installed at DeWitt, Auburn, Sibley and Bradley stations.

THESE FARREL SPEED INCREASERS WORK DAY AND NIGHT WITH ONLY ONE MAINTENANCE SHUTDOWN A YEAR



Five of these Farrel speed increasing units, installed in five different Illinois stations of Shell Products Pipe Line, have operated continuously, 24 hours a day, for more than five years, shutting down only once each year for routine inspection and maintenance or as required by pumping schedules.

Such outstanding performance is not unusual for Farrel speed increasers. Although hundreds and hundreds of these units have been furnished for pipeline pumping service, not one has ever failed on the job. In fact, every unit installed since 1932, when the line was first developed, is still operating successfully.

For further details of these proved-on-the-job speed increasers, send for a copy of bulletin 448A. No cost or obligation.

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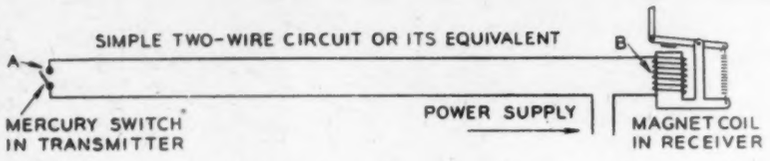


FIG. 2. Simple telemeter circuit.

maximum. At any intermediate pressure value, the switch is closed for a proportional amount of time.

Fig. 2 shows how the mercury switch of the telemeter transmitter fits into the telemeter circuit, and how it energizes the magnet coil in the telemeter receiver. The telemeter receiver converts the electrical signal to mechanical motion by means of an electrical magnet. The motion of the electromagnet's armature actuates a break arrangement controlling two differential gear assemblies, which, in turn, move an indicating pointer or pen up or downscale. During the transmission cycle, when no signal is transmitted, the electromagnet is de-energized and one of the differential gear trains is actuated. During the portion of the cycle the signal is transmitted, the electromagnet is energized, the first gear train is at rest, and the second one actuated. Through a concentric gear arrangement, motion is brought out to the pointer or pen. The indicating pointer or recording pen changes its position only when changes occur in the transmission signal, resulting from changes at the transmitter.

Fig. 3 is a telemeter round-chart recording receiver with the door open. In the upper left-hand corner is visible the electromagnet referred to in Fig. 2 and the preceding paragraph. It is shown attached to the mechanism containing the brake and differential gear assemblies. Also visible is a connecting link between this mechanism and the mounting.

The transmission circuit can be wires strung by the gas transmission or distribution company, or circuits rented from a telephone or telegraph company. Sometimes carrier current transmission over wires is used, or a microwave radio system purchased. A study in economics and operational efficiency should determine the transmission circuit to be used. We should also include with the transmission circuit a power supply for energizing the circuit.

Remote Control

Remote control makes it possible for a dispatcher to change settings of a remote controller in accordance with readings on his telemeter receiver, and thus obtain complete centralized dispatching.

A remote control system consists of a remotely located controller, and a transmission circuit with necessary power supply. Again, as for the telemeter, the transmission circuit can be a metallic circuit, carrier current, or microwave radio system. The control switch is a double-pole, double-throw switch with three positions: A "raise" position, a "lower" position, and a "neutral" position to which it automatically returns when released.

A controller incorporating a remotely positioned set point is shown in Fig. 4. In the right-hand side of the case is the proportional or reset action free-vane control mechanism, the supply for which can be either compressed air or gas. The free-vane of this mechanism is positioned by the primary measuring device which, in this picture, is a pressure element, but might be any other type of measuring device. Normally, the set point of such a controller would be manipulated by hand adjustment. But recall that we now wish to make this setting from the dispatching station. To acomplish this, use is made of a hermetically sealed, fully enclosed polarized

FIG. 3. Telemeter round-chart recording receiver.

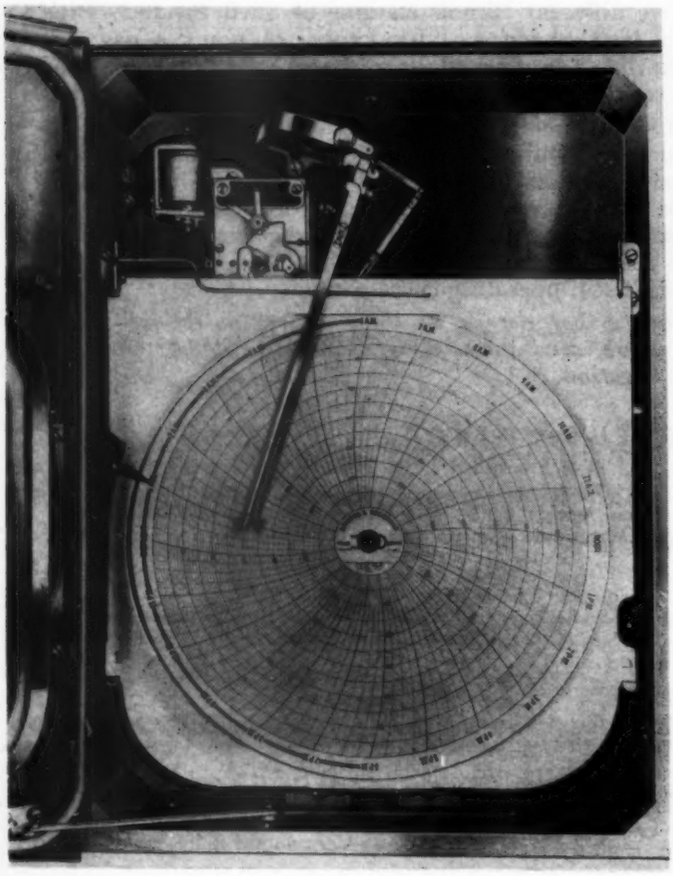
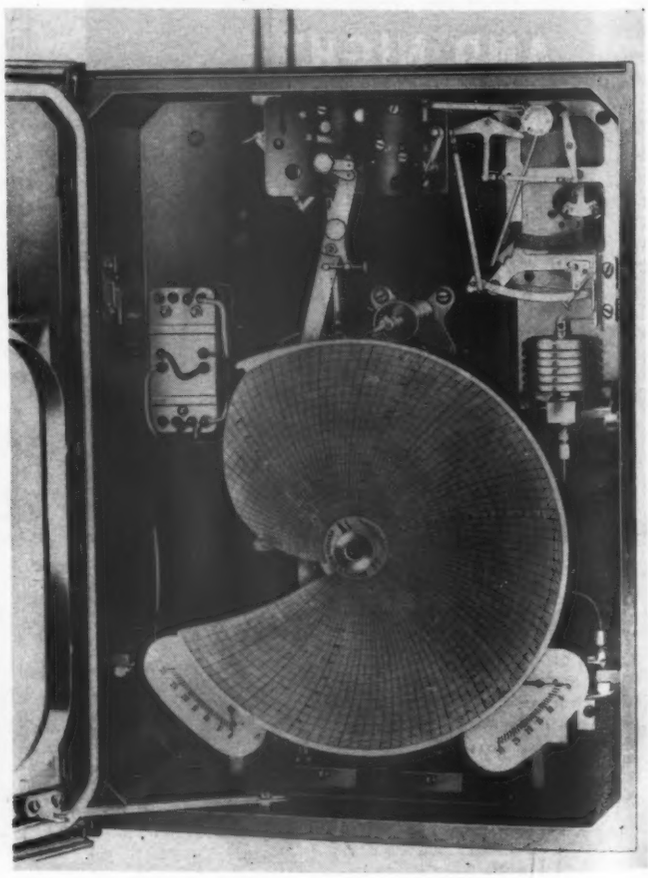


FIG. 4. Proportional action controller.



Here an Allis-Chalmers HD-15, owned by O. R. Burden Construction Corp. handles 22-inch pipe during doping and wrapping on a job near Quincy, Ill.

"Right for pipe" on 5 Big Counts

New Allis-Chalmers HD-15 Side Boom Tractors

Pipeliners and tractor operators report this new Allis-Chalmers HD-15 with heavy-duty Tractomotive side boom handles every pipe-handling operation — stringing, cradling, attaching river weights, bending, assisting cleaning and priming or doping and wrapping machines, lowering pipe into the ditch. And here are the features of this new pipeline workhorse that users say are outstanding:

1. Big Lifting Capacity. Weighing 53,700 lb. (including boom) and packing 109 drawbar hp. the HD-15 side boom tractor has the lifting capacity, safety and stability expected only in the largest tractors. It can hoist a 77,500-lb. load at 4 ft. overhang. Heavy-duty, all-steel frame is built extra strong to take the strains and stresses of booming out on lowering in work.

2. Maximum Flotation. Extra long track and 84-inch tread give the HD-15 extra stability and maximum flotation in mud and tough going. Seven truck wheels for each track mean smooth, easy rolling. Double reduction final drive and smooth, clean bottom construction provide extra clearance which permits skimming over obstructions that might otherwise "hang up" a tractor.

3. Operator and Crew Safety. This precision-balanced, tractor-side boom combination provides safety features that inspire real confidence from operator and pipe crews — cable guards in front of operator . . . safety-link, drop-proof counterweights . . . positive locking winch controls . . . massive winch drum jaw clutches . . . precision internal expanding brake shoes . . . automatic boom stop.

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See your Allis-Chalmers dealer for complete details.

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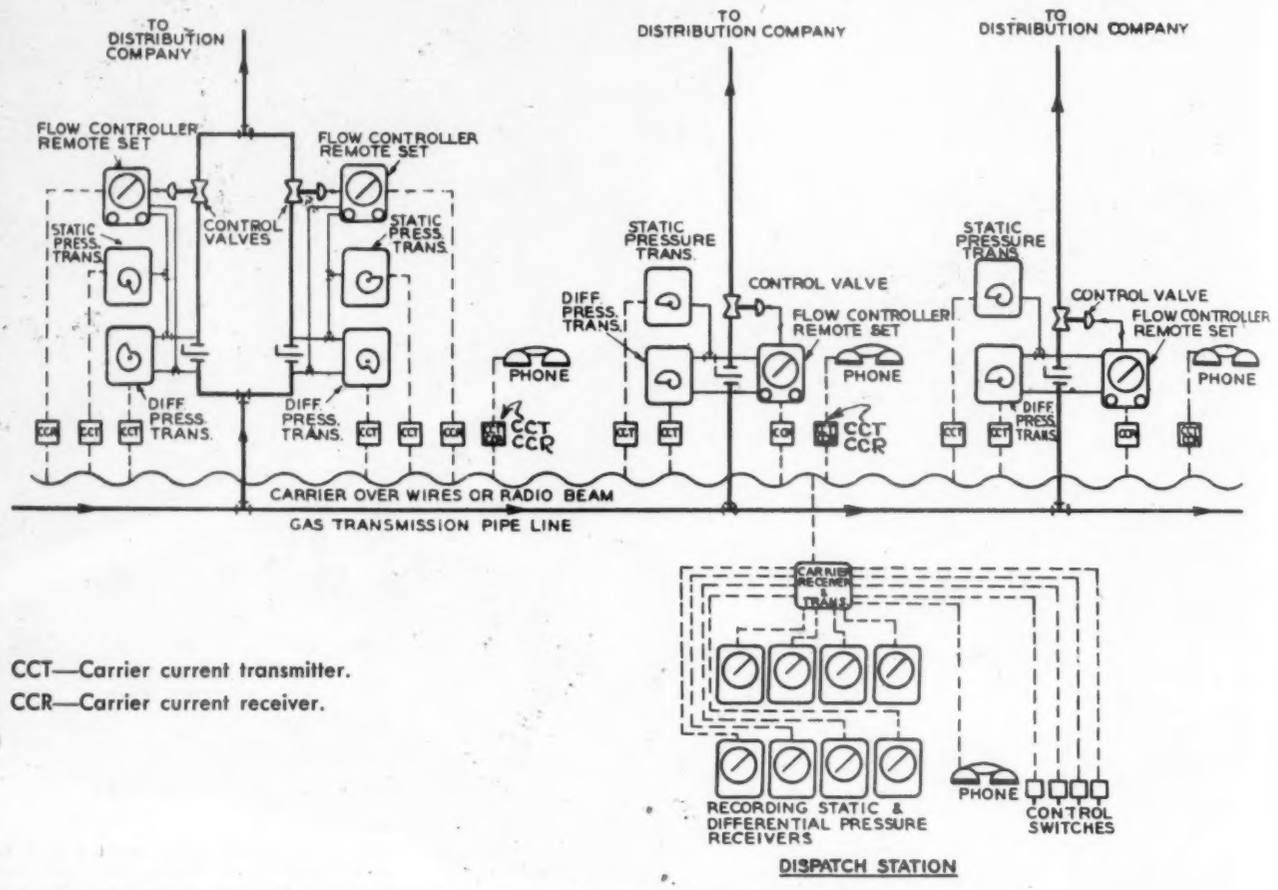


CCT—Carrier current transmitter.

CCR—Carrier current receiver.

FIG. 5. Simplified circuit diagram of a typical centralized gas dispatching system.

relay, situated in the left side of the controller case, actuating a reversible cam drive, which is in the lower central portion.

The set-point positioning cam is mounted on the shaft of the reversible cam drive under the knurled nut. This cam actuates the cam follower, which positions the set point of the control mechanism.

The armature of the polarized relay assumes one position with current flow in one direction and a second position with current flow in the opposite direction. This, in turn, controls the direction of rotation of the cam drive. The hermetically sealed relay is used for the purpose of eliminating the explosion hazard of open electric contacts.

Let us assume that pressure readings on the dispatcher's telemeter receiver are too low and it is desired to increase the pressure. The control switch in the dispatcher's office is manually held in the "raise" position, which causes current to flow through the polarized relay in the controller so that its cam drive rotates the cam in a counterclockwise direction, thereby raising the set-point position.

If the controller is to adjust loading of a weighted-arm type of gas regulator, the controller's output, air or gas, is applied to a diaphragm operator, and this positions the weight-arm of a gas regulator. In the case of a pilot-loaded type of gas regulator, the output of the controller actuates the pilot. That, in turn, loads the gas regulator. In either case, a form of control known as "cascaded control" results. If any ordinary pneumatically loaded valve is the terminating device the output from the controller is piped directly to the diaphragm top of the valve.

Because the cam rotation is comparatively slow, the resulting change in pressure or flow can be seen by the dispatcher on his telemeter receiver chart.

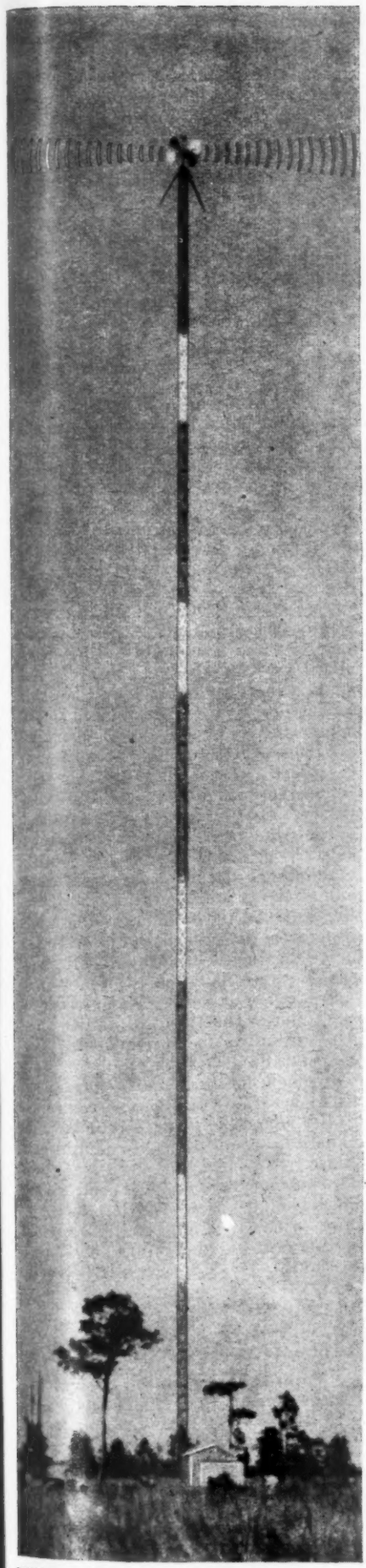
The controller set point is changed only while the reversal switch is held in a "raise" or "lower" position. Upon release, the switch returns to its neutral position and no current flows through the transmission circuit connecting the dispatching station with the remote metering station. Because of this feature, the transmission circuit could be accidentally opened, and the controller would continue to control at the set point that existed at the moment of failure. Also, a short circuit of the transmission lines would have no effect on the set-point position, inasmuch as the d-c power supply is at the dispatching station so the polarized relay would merely be shunted. If an a-c power circuit accidentally comes in contact with the remote set-point positioning circuit, the polarized relay will merely chatter and will not affect the set point. As an added protection, low current fuses are included in the circuit. The operating current for both telemetering and set-point positioning is low, being in the order of 50 milliamperes direct current per circuit. A further precaution is added when carrier currents are used, inasmuch as the set-point position can be changed only when the particular carrier frequencies are generated.

Application

Many gas pipe line companies are now controlling gas flow to various distribution companies along their lines, from central dispatching points, by means of remote control and measurement. Fig. 5 shows a typical example of this.

At the left-hand end of the pipe line is a take-off point feeding a distribution company through two metering runs. Connected to each run is a differential pressure transmitter, a static pressure transmitter, and a flow controller, the set point of which can be varied from the dispatching station. These variables are transmitted by carrier currents either over a wire circuit or by means of a microwave radio beam to the dispatching station.

The dispatcher can see what differential pressure and static pressure exist at any moment on a particular meter run and, if necessary, vary the control valve by means of a manual switch on his switchboard. By this method, he is able to regulate the amount of gas flow to a



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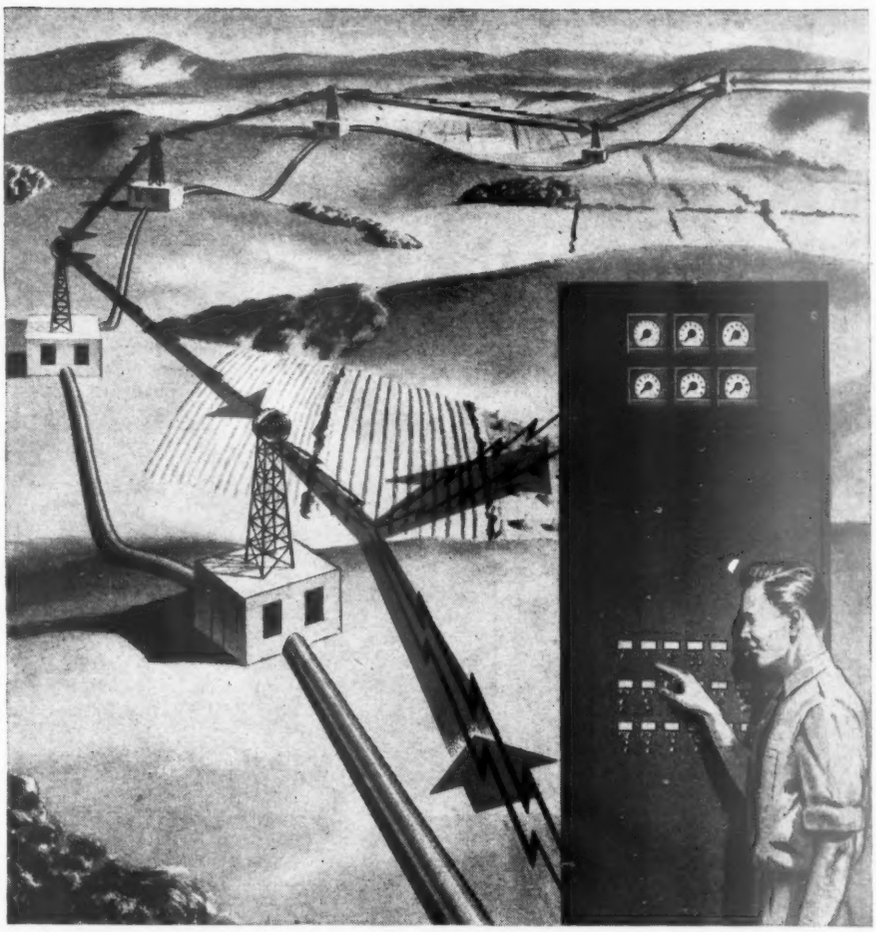

UNATTENDED STATIONS are controlled by microwave from dispatcher's office. Motors are switched, valves adjusted, station information relayed.

Microwave remote control holds pumping costs down

G-E engineering co-ordinates complete system to improve station operation, boost throughput

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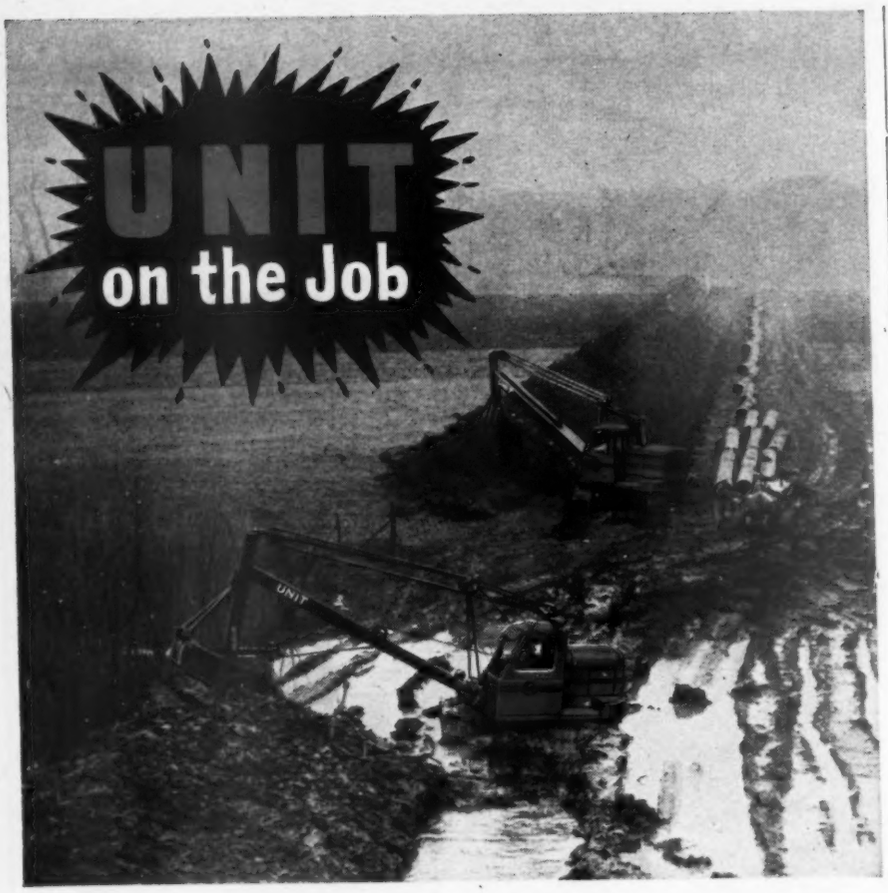

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distributing company in accordance with contact arrangements between the pipe line company and distributor. The dispatcher also can close off one of the meter runs of the left-hand take-off point during periods of low flow to the distributor, thereby getting more accurate reading of differential pressure, and can open the second run when required by increased demand.

Records of static and differential pressures can be recorded on separate charts or the differential and static pressure for each meter run can be recorded on the same chart by means of a two-pen receiver, allowing the use of an integrator for determining corrected flow. A telephone is available at each metering station and is connected by carrier to the centralized dispatching station so that maintenance personnel working at a metering station can be contacted if desired. Although only three take-off points are shown, many more could be controlled from the central dispatching station over the single pair of wires or radio beam.

Remote measurement and control can also be extensively used in gas distribution. Picture a large industrial city whose gas is supplied by a gas pipe line company. Gas flows from the pipe line lateral through city gate stations and out into the distribution lines. For this application, importance is placed on the maintenance of pressures throughout the distribution system, regardless of load variations. At each city gate are telemeter transmitters and remote-set controllers. The telemeter receivers and control switches are in the gas company's dispatch office.

Additional telemeter pressure transmitters are located at various low-pressure points in the system, to inform the dispatcher of system conditions. All these measurements and controlling means are available on the centralized control panel at the gas company's dispatch office. Thus, control of the complete system can be accomplished from one centralized location.

In conclusion, it might be mentioned that remote measurement and control is readily adaptable to oil pipe lines and refineries as well as to the natural gas industry.

Remote measurement and control simplifies and increases operating efficiency of any widespread industrial process by offering centralized readings and fingertip control. * * *

* * *

French Gas Costs Beaucoup

Eighty-cents a gallon gasoline faces the motorist in France now. An 18 per cent hike in the gasoline tax recently imposed by the French government gives that country the highest-priced motor fuel of any country in the world except Italy. French gasoline is roughly three times as costly as gasoline in the U. S. This is true despite the fact that taxes have risen here, too, until they total, on the average, about one fourth of the total retail price.

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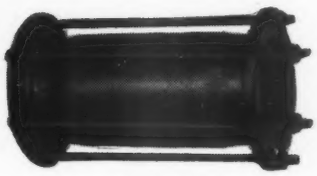

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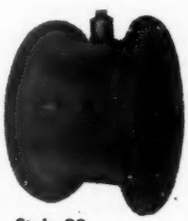

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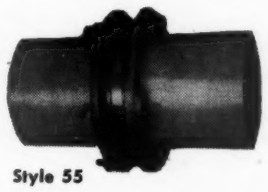

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Natural Gas—Cinderella to Glamour Girl

The story of gas from its insignificant beginnings to the present with its 342,500 miles of pipe lines, 193.8 trillion cubic feet of reserves, and 17,600,000 customers, is a fabulous one.

AMERICA is a land of rags to riches opportunity. Its economic history is star-studded with examples of Cinderella industries. Oustanding among these is the Cinderella natural gas industry, regarded 25 years ago as a poor relative of the oil industry and today attracting more than one billion dollars a year of invested capital to finance its continued growth. Few industries can boast of doubling in size in a single decade. The gas industry had five billion dollars invested in plant and equipment at the beginning of 1945. It will be a ten billion dollar industry before the beginning of 1955. The greater part of this tremendous growth has been in the natural gas branch.

If natural gas were a new commodity, the phenomenal rise of this giant energy source would be remarkable. What makes the story almost miraculous is the fact that natural gas in one of the nation's oldest industries. Natural gas itself is as old as civilization.

History records that as early as 940 B. C., nearly 500 years before Socrates was born, the Chinese had discovered natural gas and were piping it through hollow bamboo rods to evaporate brine to produce salt.

In this country, George Washington, in dedicating a tract of land in West Virginia in 1775 for a national park, commented on the "burning spring" existing in that area. This was situated in the valley that was to become the heart of the nation's first natural gas region a century later, the Appalachian natural gas fields.

The first natural gas well drilled in this country was at Fredonia, New York, in 1821. The well was 27 ft deep and was "capped" with a large tin barrel to maintain pressure. Four years later the Marquis de Lafayette on a visit to Fredonia, found the town lighted with natural gas and a dinner in his honor was cooked over gas at the hotel.

In 1826 another crude natural gas well was drilled along the shore of Lake Erie at Westfield, New York. A wooden pipe line, half a mile long, was built to carry gas to the lighthouse at Barcelona Harbor, New York. It is reported that this well kept 144 burners illuminated for more than 25 years.

In 1840, following the example of the Chinese, natural gas was utilized in Butler County, Pennsylvania, in evaporating brine to refine salt. The following year a farmer in West Virginia encountered natural gas at a depth of about 700 ft while boring for a salt well. He piped the gas to burn under evaporating pans in manufacturing salt. Thus, salt refining appears to be the first commercial use of natural gas.

The first recorded corporation organized to serve natural gas was the Fredonia (New York) Gas Light and Water Works, formed in 1858 to sell natural gas to business and residential customers. At that time, however, about 300 companies had been formed in America to manufacture gas from coal. These companies served nearly 5,000,000 customers, about one-sixth of the nation's population at that time.

Oil was discovered in western Pennsylvania in 1859, and in the oil rush that followed, natural gas was developed to a minor extent. Little demand existed for this new fuel, and often it was piped away from the oil wells and burned to get rid of it. This "flaring" of natural gas later became so prevalent in the Southwest that Texas and other natural gas states passed laws prohibiting flaring of natural gas as a conservation measure.

Natural gas was first discovered in usable quantities in California in 1864 by persons drilling a water well in Stockton, in the northern part of the state. The gas produced was used in the County Court House and the well produced up to 1895. This was the first of about 33 wells drilled and utilized in and around Stockton from 1864 to 1917.

Line of Pipe Logs

The first "long-distance" pipe line was built in 1870. It was made of 8-in. holes bored in white pine logs and it cost about $1,500,000. It carried natural gas about 25 miles, from West Bloomfield to Rochester, New York. The project was given up as a failure after a couple of years.

Iron pipe was utilized for the first time in carrying natural gas in 1872, when a 2-in., 5½-mile line was built from the Newton Wells to Titusville, Pennsylvania. This line delivered 4,000,000 cu ft a day to about 250 domestic and business customers. In the same year, the American Gas Light Association, the predecessor of the American Gas Association, was formed at Cleveland, Ohio.

The next decade witnessed the formation of the first companies to build pipe lines and transport natural gas. One of the first of these was the Stockton (California) Natural Gas Company formed in 1886. Most of these companies brought the gas from wells but did not sell it to consumers. As late as 1890, natural gas lines were still small in diameter, mostly under 8 in., and extended relatively short distances.

The first natural gas transmission line that could be classified as a "long-distance" pipe line was built in 1891 of 8-in. iron pipe. It extended 120 miles from gas fields in northern Indiana to Chicago, and carried natural gas at a working pressure of 525 psi. This was the nation's first high pressure natural gas line.

At the turn of the 19th century, the discovery of the incandescent lamp and the introduction of electricity for lighting threatened to finish the gas industry. But the industry, particularly the manufactured gas companies, now had too much at stake to accept extinction through default. It was discovered that gas was an ideal fuel for cooking and water heating, and the industry flourished anew.

The natural gas industry, however, remained dormant. By 1900 natural gas has been discovered in 17 states, but the total production for that year was sold for less than $25,000,000. Pennsylvania then was the largest natural gas producing state.

Gulf Coast Opened

The following year Captain Anthony F. Lucas, one of America's first "wildcatters," or independent prospectors, discovered the famous Spindletop field near Beaumont, Texas. This discovery opened the rich Gulf Coast natural gas area. At that time, natural gas pipe lines, made of iron, were very costly, and were mostly limited to 300 miles in length.

In 1906, total consumption of natural gas was about 339 billion cu ft. Natural gas was discovered in the Buena Vista Hills in California in 1910 and was piped 40 miles to Bakersfield. Exploration was begun that year in the Kettleman Hills region, but it was not until 1928 that natural gas was brought in here in what proved to be California's richest producing area. The producing area began to move away from the Appalachian and upper New York region.

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Now Texas and California produced the largest part of the natural gas used in this country. In 1910 production rose to 509 billion cu ft. Ten years later production had gained only 300 billion cu ft, for in 1920 total production of natural gas was about 800 billion cu ft. In 1925, about 3,500,000 customers were receiving natural gas, but most of these customers were situated within a few hundred miles from fields producing gas.

The size of pipe lines had begun to increase. In 1909 the Hogshooter gas field was discovered in northern Oklahoma, and a 16-in. pipe line was laid to bring gas to Joplin, Missouri, and Kansas City. In the same year natural gas was delivered for the first time to Cincinnati by a 20-in. pipe line, extending about 185 miles to the fields of West Virginia; but most markets were still far from the gas fields. Even today, out of the 3,000,000 square miles constituting our country, natural gas fields cover only about 22,000 miles.

Natural gas production in the Southwest began to assume big proportions. The famous Glenpool in Oklahoma was discovered in 1905. The same year saw the discovery of the Caddo field in Louisiana. In 1906, a group of natural gas men met in Kansas City to form the Natural Gas Association of America, which merged in 1927 into the American Gas Association.

This was the year that the Louisiana state legislature passed a law making it a crime to burn or flare natural gas from any well within the state. It was a common sight to see fires burning 24 hours a day in the oil fields, from tops of pipes stuck into the ground. Natural gas at that time was considered to have little value in the Southwest. It interfered with the production of oil wells, and was burned as waste material.

In 1910, the U. S. Bureau of Mines was established and it began to disseminate information concerning natural gas and oil. The Oklahoma fields became the source of supply for several new pipe lines and the state tried to adopt legal measures to prevent exportation of gas, but was unsuccessful. Three years later, however, the Oklahoma state legislature did pass a law rating the production of natural gas from common reservoirs in the state. This is believed to be the first conservation regulation of that type ever adopted.

Welded Pipe Lines

In 1911, acetylene-oxygen welding of pipes made it possible to build natural gas pipe lines up to 300 miles, though the process was still very costly.

Underground storage of natural gas in depleted gas wells was first attempted in 1916 at Concord, New York, and the gas stored there was piped 30 miles to Buffalo, when needed to meet heavy demands on cold winter days. This was the forerunner of a practice that may contribute greatly to the final determination of the economics of using natural gas for house heating in eastern markets.

The first reliable estimate of recoverable natural gas reserves was made in 1919 by a geologist named E. W. Shaw. He placed the nation's entire proved natural gas reserves at 15 trillion cu ft. At the end of 1951 the Natural Gas Reserves Committee of the American Gas Association, comprised of the leading geologists and natural gas industry executives, estimated the proved recoverable reserves of natural gas in the United States were in excess of 193.8 trillion cu ft. This was a net gain of 8.2 trillion cu ft over the previous year, after deducting a record production of 8 trillion cu ft during the year of 1951. Natural gas reserves have gained nearly 100 trillion cu ft in the last 10 years. In 1919 consumption of natural gas was about 746 billion cu ft. Last year's production of 8 trillion cu ft was 24 times the total amount of hydro-electric power generated in this country. Natural gas now supplies nearly 25 per cent of the total energy used in this country each year.

Long distance natural gas transmission lines got their real start in 1925, when seamless, electrically welded pipe became available to the industry. Gathering and transporting natural gas became profitable, and by 1930 the consumption of natural gas had risen to 1.9 trillion cu ft.

The extending pipe line systems began to bring natural gas to cities formerly served with manufactured gas. In 1931, Washington, D. C., used natural gas to mix with manufactured gas of about 600 Btu. Fifteen years later, in 1946, the Washington Gas Light Company, one of the pioneer gas companies in the country, began its changeover to straight natural gas distribution.

Natural gas came to Chicago in 1931 through one of the nation's first transcontinental lines. The Natural Gas Pipe Line Company of America built a 24-in. welded steel line, more than 1000 miles long, to bring natural gas from the Texas Panhandle to The Peoples Gas Light and Coke Company of Chicago. This company, almost a century-old manufactured gas company, used the natural gas to form an 800 Btu mixed gas.

Construction of the Panhandle Eastern Pipe Line Company's line from the Hugoton field in Kansas and Texas to Rockville, Indiana, was completed in 1931. An intermediate line to Muncie, Indiana, connected with the Columbia Gas System and through this line the first Texas gas was brought to eastern markets. Although this was a depression year, the natural gas industry in 1931 built about 7700 miles of pipe line at a cost of $318,265,000 and used nearly 75 per cent of the steel pipe tonnage produced that year. This represented an average cost of about $41,350 per mile. Today it costs nearly $150,000 to build a mile of large diameter pipe.

More cities were changing from manufactured to mixed gas or to straight natural gas. Minneapolis and Detroit began using natural gas about 1935. This was the year that the Interstate Oil Compact Commission was formed with six charter states—Texas, Oklahoma, Illinois, Kansas, New Mexico, and Colorado.

The purpose of the agreement was to prevent waste of natural gas and oil and Congress approved the Interstate Compact in 1935. In 1938 it passed the Natural Gas Act. This marked the entry of the federal government into the field of regulatory control of the natural gas industry. Four years later the Act was amended to provide for the issuance of certificates of public convenience and necessity for the extension, acquisition, and operation of natural gas pipe lines. In this manner the federal government was able to control the construction of new interstate pipe lines. Proof of source of supply, financial responsibility, and potential markets over a period of 20 years or the extent of the proposed loans, is required by the Federal Power Commission before certificates will be granted.

Some of Major Lines

Construction of the Big Inch line was begun in 1942. This line was built as an oil carrier, to bring needed oil to the eastern seaboard in World War II. It took a year to construct the 1340 mile line and the cost to the federal government was $78,500,000. The following year saw the construction of the Little Big Inch to carry gasoline and other oil products from Beaumont, Texas, to Linden, New Jersey, a distance of about 1475 miles. The Little Big Inch cost $67,300,000.

Four years later, in 1947, the Texas Eastern Transmission Corporation acquired both the Big Inch and the Little Big Inch at a cost of $143,127,000, and by installing compressor stations about every hundred miles, converted the oil line into a natural gas transmission line. This purchase was the largest cash transaction in the history of the gas industry up to that time.

During the World War II, the Tennessee Gas Transmission Company built an 1265-mile line from Texas to West Virginia at a cost of $54,000,000 and this had been the longest transmission line for natural gas in the country until the conversion of the Big Inch and Little Big Inch lines. The Tennessee Gas Transmission line was constructed as part of the war program to augment the natural gas supply in the highly industrialized Appalachian area. It is still one of the most important transmission lines in the country.

In 1947 another important link was forged in the chain of natural gas transmission lines that were crossing the country when the El Paso Natural Gas Company began supplying Southern California Gas Company and Southern Counties Gas Company with natural gas from Texas. The Biggest Inch, so called because it was the first 30-in. pipe line, brought the California companies gas from the Hugoton-Panhandle field. The line was composed of 24-in., 25-in., and 30-in. pipe, extending 1200 miles. The final link of 213 miles of 30-in. pipe gave the line its name.

In June, 1949, construction was started on the Super Inch, the largest diameter pipe line in the world for high-pressure transmission of natural

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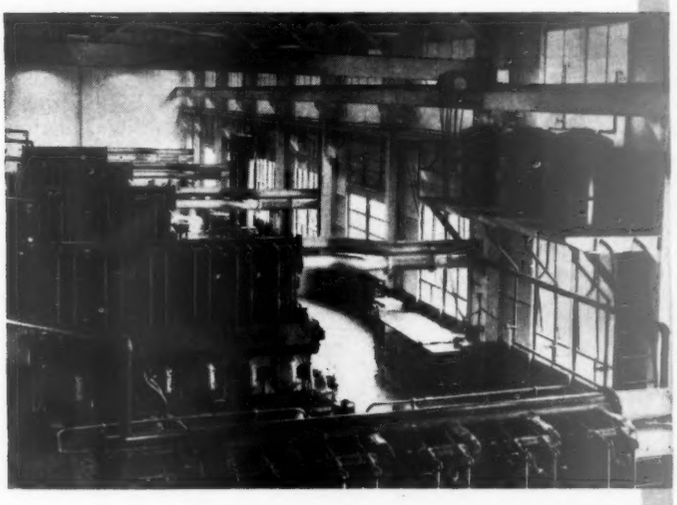

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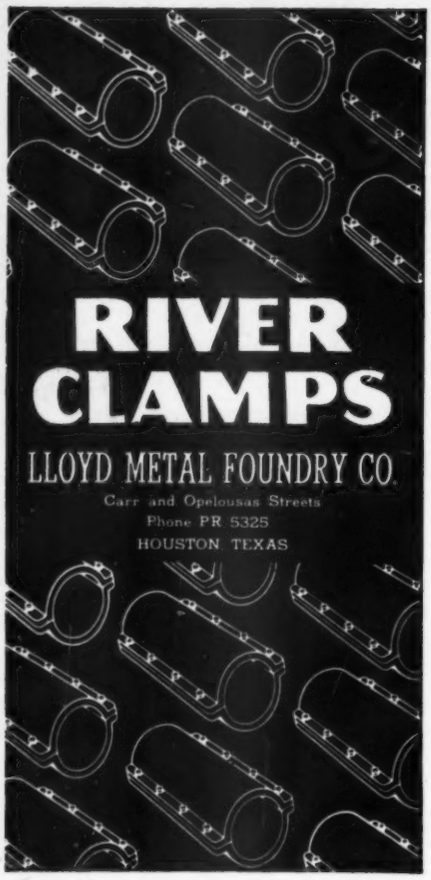

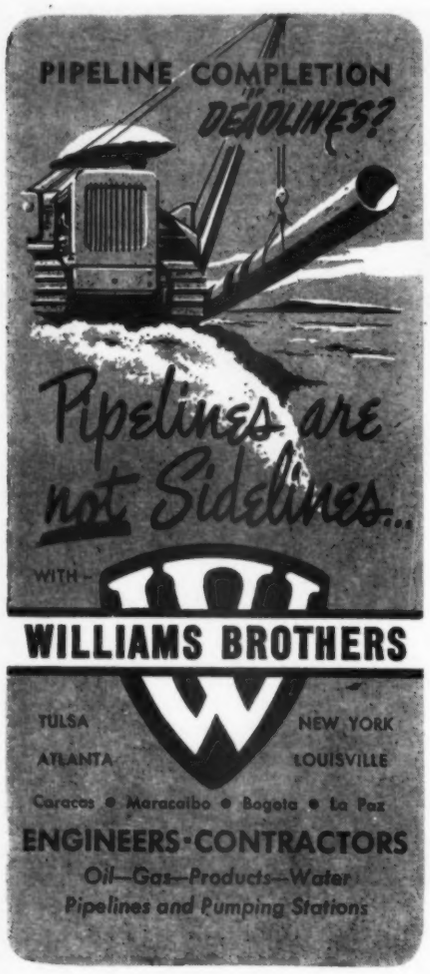

gas. The Pacific Gas and Electric's new line was 34 in. in diam, and 502 miles long. It comprises an important section of the 1600-mile system bringing gas from Texas and New Mexico to northern and central California. The cost of the new line, which went into operation late in 1950, was about $63,000,000. The eastern portion of the system was built by the El Paso Natural Gas Company. Initial deliveries of the Super Inch were 250,000,000 cu ft a day. The addition of new compressor stations at a cost of $12,000,000 brought daily capacity up to 400,000,000 cu ft a day. Pacific Gas and Electric has pending an application to increase deliveries over Super Inch by an additional 150,000,000 cu ft a day. Cost of compressor expansion and pipe line looping would be another $13,500,000.

The next huge transcontinental line completed was the $235,000,000 line built by the Transcontinental Gas Pipe Line Company bringing gas more than 1840 miles from Hidalgo County in Texas to Metropolitan New York. Some natural gas had been delivered to the New York and Richmond Gas Company on Staten Island by the Texas Eastern's Big Inch line in the latter part of 1949, but New York City and Brooklyn received their first natural gas through the Transcontinental line on January 16, 1951. The Consolidated Edison Company of New York, Inc., uses natural gas to supplant oil for enriching manufactured gas in Manhattan, though its Westchester, New York, division and part of the Bronx have been converted to straight natural gas. The Brooklyn Union Gas Company has converted to straight natural gas following the example of such cities as St. Louis, Baltimore, Washington, D. C., Milwaukee, and others.

Delivery of natural gas to New England has begun, with part of Massachusetts, Rhode Island, and Connecticut now receiving natural gas. The battle between the big natural gas transmission companies for the right to serve this new market was reminiscent of the pitched battles waged by the railroads in the last century. In the present case legal talent and lobbying replaced the brawn and gunpowder that often accompanied the spread of the railroads across the country. Two companies have been approved by the courts to serve New England. Litigation still is pending as to the final authorization on this matter.

Natural gas was brought to the South Atlantic states through extensions and new lines built by such companies as Southern Natural Gas Company, United Gas Pipe Line Company, Transcontinental, and others. Today natural gas is being served to more than 16,000,000 customers in 39 states. The Pacific Northwest states and Maine and Vermont in the New England group are the only regions in the United States not receiving natural gas or not covered by certificates from the FPC assuring delivery in the near future.

It is expected that authorization will be granted to serve the two New England states as soon as legal obstacles and restrictions of steel pipe are removed. It also is believed that the Pacific Northwest will receive natural gas either from the Southwest or from Canada before the end of 1953.

Production Triples

The production of natural gas during the last 15 years has more than tripled. In 1937, production amounted to about 2.5 trillion cu ft. At the beginning of 1952, production was at the rate of 8 trillion cu ft annually, and will be well over the 9 trillion cu ft mark at the end of the year. In 1937, natural gas supplied about 20 per cent of the fuel energy of the nation. Today it supplies about 25 per cent and would be more if all existing demand for natural gas in home and industry could be filled.

This accelerated demand has necessitated a tremendous expansion in natural gas facilities. In the five years from 1947 through 1951, the gas industry spent $5,146,000,000 for construction of new plant and in expanding present facilities. Of this amount, $4,560,000,000 was spent by the natural gas industry. Nearly $3 billion was spent on natural gas transmission lines. It has been estimated by the Bureau of Statistics, AGA, that in the five years from 1952 through 1956 the gas industry will spend a record $5,595,000,000 on new construction, with about $5,099,000,000 of this amount being devoted to the natural gas expansion program.

In 1951 the natural gas industry spent $1,363,000,000 on new plant and equipment. Transmission facilities cost $867,000,000 and $42,000,000 was spent for expansion of underground storage facilities. Shortages of materials and some difficultjes in obtaining allocations are expected to bring a temporary abatement of the industry's construction program in 1952 when the gas industry expects to spend about $1.17 billion on new construction. Estimates indicate that the construction program for 1953 of $1,681,000,000 will reach an all-time high level in gas industry history. Of the record 1953 total, about $1,571,000,000 will be spent on natural gas expansion.

This huge investment has resulted in a tremendous growth in the mileage of the natural gas pipe line system. During the years 1950 and 1951, the Federal Power Commission authorized construction of a total of 13,500 miles of new transmission pipe lines. Applications at the end of 1951 amounted to more than 10,000 additional miles. Today the nation's natural gas pipe line system, including gathering and distribution lines as well as the long-distance transmission lines, total 342,500 miles, making it one of the greatest transportation systems in the country.

The spectacular increase in the invested capital of the natural gas industry has been the result of gains in demands in all three fields, residential, commercial and industrial. At the end of 1942 there were about 8,200,000 natural gas customers. Today it is estimated that nearly 17,600,000 customers,

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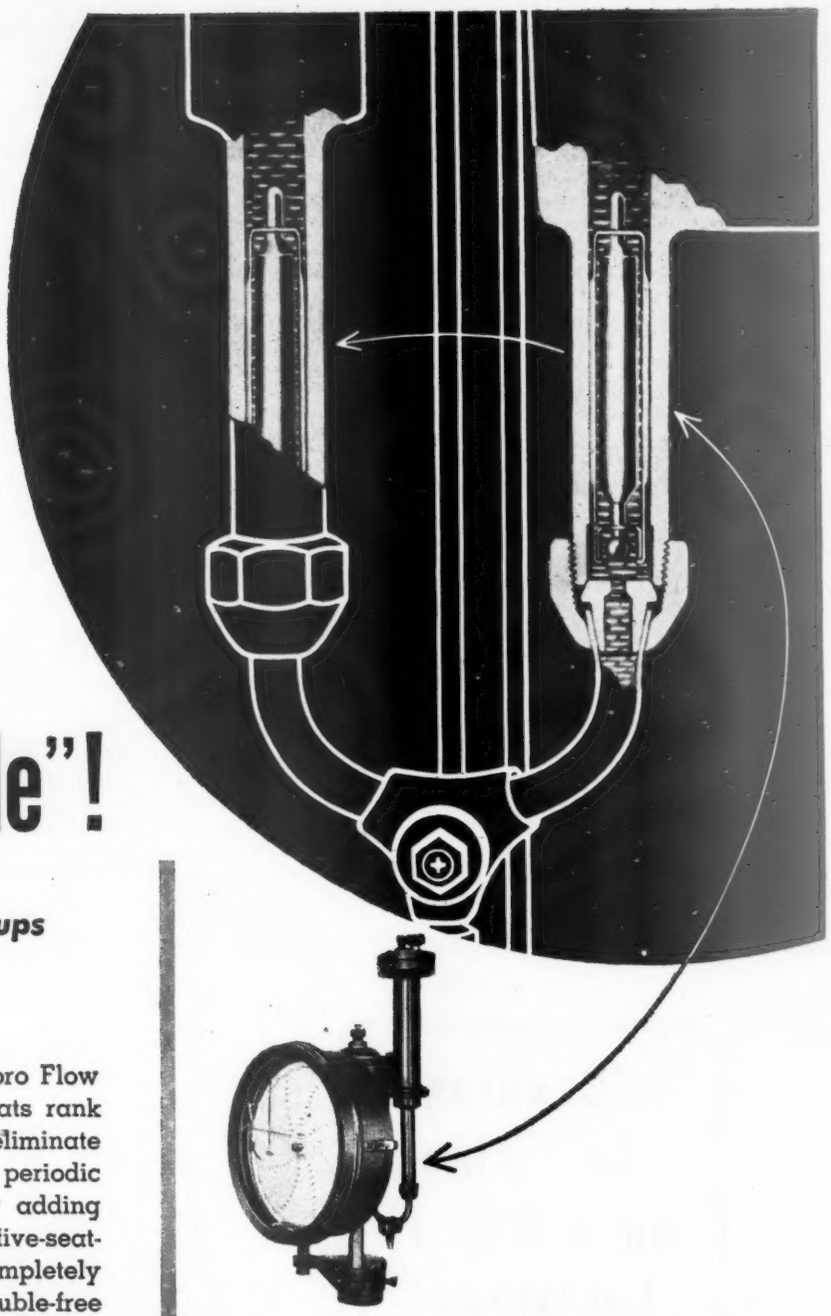

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more than double the number of 10 years ago, are receiving natural gas.

Gas househeating continues to be one of the fields of greatest demand. In some areas it has proved to be somewhat of an economic problem. In areas served by straight natural gas, it often is a premium fuel, selling lower than competitive fuels, despite rising costs such as taxes, wages, and increased costs of materials, that affect natural gas companies as well as those of competitive fuels. The low cost, flexibility, and cleanliness of natural gas have put it in great demand.

The gas utilities now serve more than 10,500,000 customers with gas for all types of househeating. A recent survey shows that 1,514,000 new househeating customers were added in the 1951-1952 heating season and that more than 1,000,000 additional customers for gas househeating can be expected to join this list in each of the next two heating seasons. Thousands of customers remain on waiting lists in areas where new sales of gas househeating are restricted because of regulatory orders or because of short supply.

Underground Storage

Underground storage of gas is proving one of the major aids in easing the problem of peak loads caused by heavy seasonal demands in winter months balanced against lighter demands in the summer. More and more gas utilities are exploring the possibilities of "underground storage banks." Depleted gas or oil fields into which natural gas from transmission lines can be pumped during warm months to meet winter peaks are being utilized in increasing quantities. It is estimated that about $82,000,000 will be spent in the next five years in expanding underground storage facilities for natural gas.

In many regions exhausted natural gas and oil wells are being cleaned and refilled with natural gas. In other areas where such depleted wells are not available, salt domes or other favorable geological formations are being converted to storage fields for natural gas. Some companies are considering possibilities of creating underground caverns, like mine shafts, for storage wells.

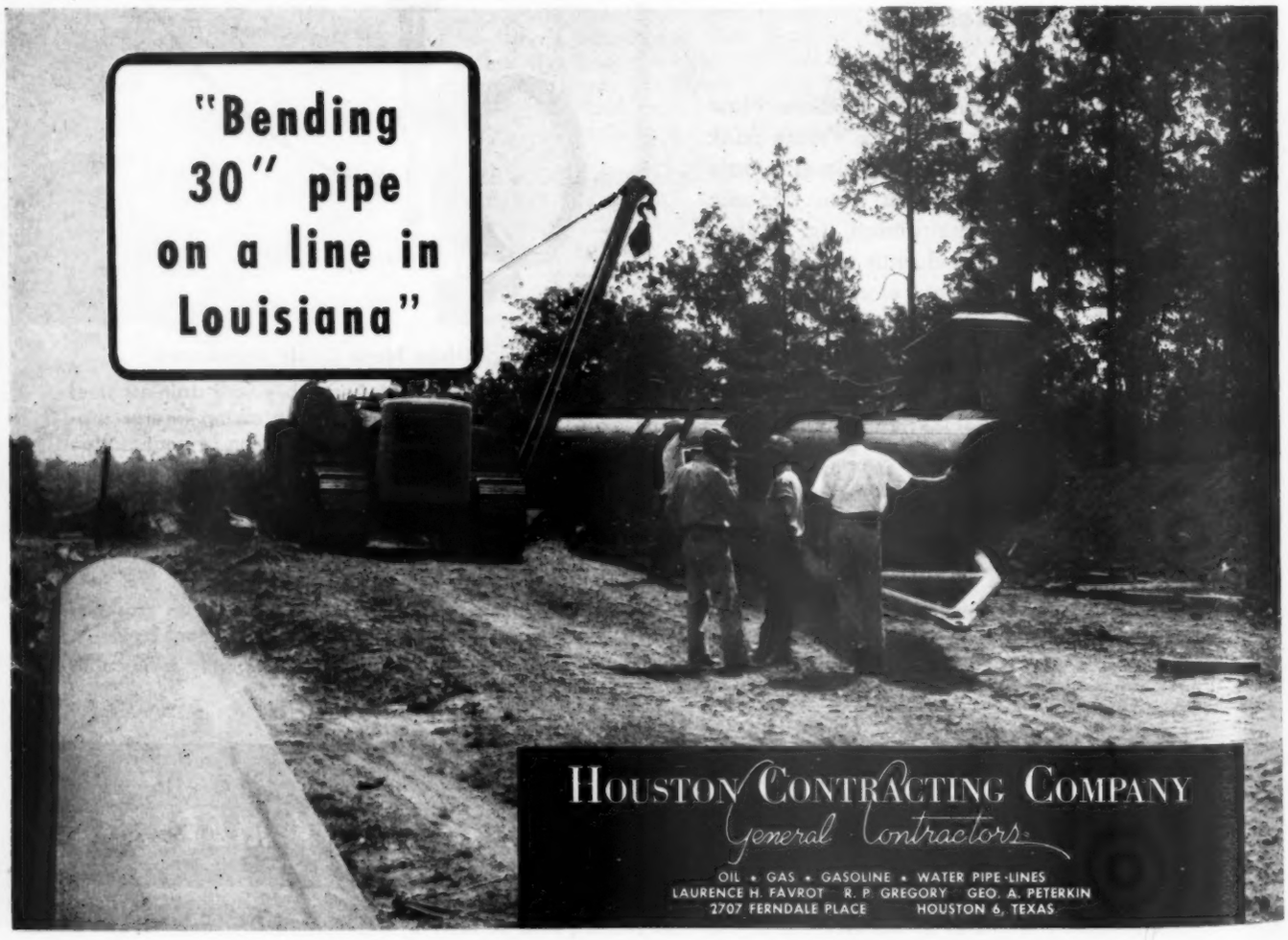
Underground storage costs can vary from 2 cents to 55 cents per 1000 cu ft in natural storage wells, depending upon the amount of rehabilitation work necessary before gas can be stored and the rate of pressure that can be obtained; however, this is much cheaper than tank storage or other above surface methods of keeping natural gas in reserve. Nearly 400 billion cu ft of natural gas are stored underground at the end of 1951. It would take 25,000 storage holders of the largest type to hold this amount. If underground storage were not available, gas utilities would have to sell large quantities of natural gas to be burned under boilers or for other industrial uses, at low prices on an interruptible basis during off-peak seasons, in order to maintain the capacity ratios necessary for transmission lines to operate at a profit.

Gas Reserves

Production of natural gas has grown by leaps and bounds, yet discoveries of new reserves and extensions of estimates of proved recoverable reserves have more than kept pace with the increased production. This has been the case each year since the American Gas Association's Committee on Natural Gas Reserves began publishing estimates in cooperation with the American Petroleum Institute's estimates of crude oil reserves.

New drilling methods are bringing in new natural gas wells in areas believed to have been depleted. Deep-well drilling in Pennsylvania and in New York State has brought in wells in abandoned areas and this has occasioned some estimates that the newly discovered reserves in some districts may be greater than the original discoveries in these areas nearly a century ago.

Off-shore reserves in the tidewater areas of the Gulf Coast are now being tapped, and trillions of cubic feet of natural gas are known to be stored there. One well-known authority has estimated that there are now more than 500 trillion cu ft of natural gas reserves in this country. This would mean at least 70 years' supply, even at today's advanced production rate. The future of the natural gas industry looks bright for many years to come. ★ ★ ★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Insulation Resistance	100,000 megohms	100,000 megohms
Operating Temperature	200 F	200 F
Adhesion	30 oz per inch	20 oz per inch
Tensile Strength	30 lbs per inch	56 lbs per inch
Elongation at Break	250%	300%

"Trantex" is a black polyvinyl tape. It is available in two thicknesses—*V-10 is a 10 mil tape for general conditions, and **V-20 is a 20 mil thickness for use where a more rugged coating is specified.

Johns-Manville TRANTEX® *polyvinyl* TAPE

PROTECTS PIPELINES AGAINST CORROSION

NO. 288 FILE NO.

TRANSMISSION LINE MAINTENANCE REPORT

LINE _____ DISTRICT _____ DATE _____

LEAKS REPAIRED

LEAK NUMBER	LOCATION OF LEAK Pit, Coupling, Threads, Etc	METHOD OF REPAIR Bond Clamp, Patch, Rerubber, Etc.
1		
2		
3		
4		
5		
6		

PIPE REPLACED

LEAK NUMBER	PIPE SIZE	LENGTH REPLACED	GENERAL CONDITION OF PIPE & HOW REPLACED (Welded; Coupled)
7			
8			
9			
10			
11			

R — —

T — —

INFORMATION FOR SURFACE DAMAGE CLAIMS

SIGNED _____

FIG. 1. Form used to make report on line repair.

P 625.

Line Name _____ Test Pressure _____ J.O. No. _____

Section No. _____ From _____ To _____

Test No. _____ Appx. _____ Mi. of _____ In.

Started Filling Line _____ A.M. / P.M. _____ 194_

Finished Filling Line _____ A.M. / P.M. _____ 194_

Pressure at Pump When Line Filled _____

Pressure Test Started _____ A.M. / P.M.

Line Failed - Pressure _____ Lbs. _____ A.M. / P.M. _____ 194_

O. N. G. Pumps Used _____ Hrs. Contractors Pumps Used _____ Hrs.

Location of Pumps _____

R

T

N

(Locate Break in Section)

Nature of Break _____

Material Used for Repairs _____

Apparent Condition of Pipe at Break

Seamless _____ Butt Weld _____ Lap Weld _____ Electric Weld _____

Pitted _____ Depth of Pit _____ Coupled or Welded _____

Estimated Condition of Pipe _____ %

Final Test: Pressure - Dead Weight _____ Rec. Gauge _____

Pressure Held on Line for _____ Hrs. _____ Min.

Pressure at End of Test _____ Lbs.

(Make additional remarks on reverse side)

Signed _____

FIG. 2. Field work sheet for recording data on water test.

Pipe Line Maintenance Procedures

Proper organization and a complete system of records essential factors in effective program

FRANK H. LOVE*

OKLAHOMA NATURAL GAS COMPANY has learned from many years' experience that proper organization and a complete system of records are two of the essential factors in a good pipe line maintenance program. Observance of these two fundamentals makes it possible to find leaks at the earliest possible moment and to repair them quickly, both of which contribute to minimizing the loss of gas. Further, utilization of these records enables anticipation of where serious trouble may develop, so that reconditioning can be done and the potential trouble averted.

Oklahoma Natural is one of the older gas systems of the country and includes in its 2561 transmission mileage pipe of various sizes and ages. Some of the lines are 45 years old, a great many are 35 years, and more still 25 years. Many of the older lines are of 2, 4, 6, 8, and 12-in. pipe, although the newer ones are of 16, 24, and 26-in. in keeping with the modern trend to larger diameter pipe lines. These facts make it obvious that the problems connected with the maintenance of such a system are multiple.

The methods adopted by this company, therefore, are important, and quite possibly may be found adaptable, at least in part, to other systems. Dissemination of such information with this possibility in view is the purpose of this article.

Organization

Organization of the supervisory personnel begins in the general offices at Tulsa, the top man, insofar as maintenance is concerned, being the general superintendent. His duties embrace transmission, distribution, operations, production, storage, and new construction, as well as the subject we are discussing, maintenance. Under him are two assistants, one of whom largely supervises distribution, the other the several additional phases of operations mentioned.

Geographically, the state of Oklahoma is divided into six districts with the central offices of these districts at Tulsa, Oklahoma City, Shawnee, Muskogee, Enid, and Ardmore. Each has a district manager, who in turn has under him a superintendent whose functions in the district correspond in scope with those of the general superintendent. Answerable to the district superintendent is a distribution superintendent and a transmission superintendent.

In the larger districts the district

*Editor, Oil and Gas Pipelining.

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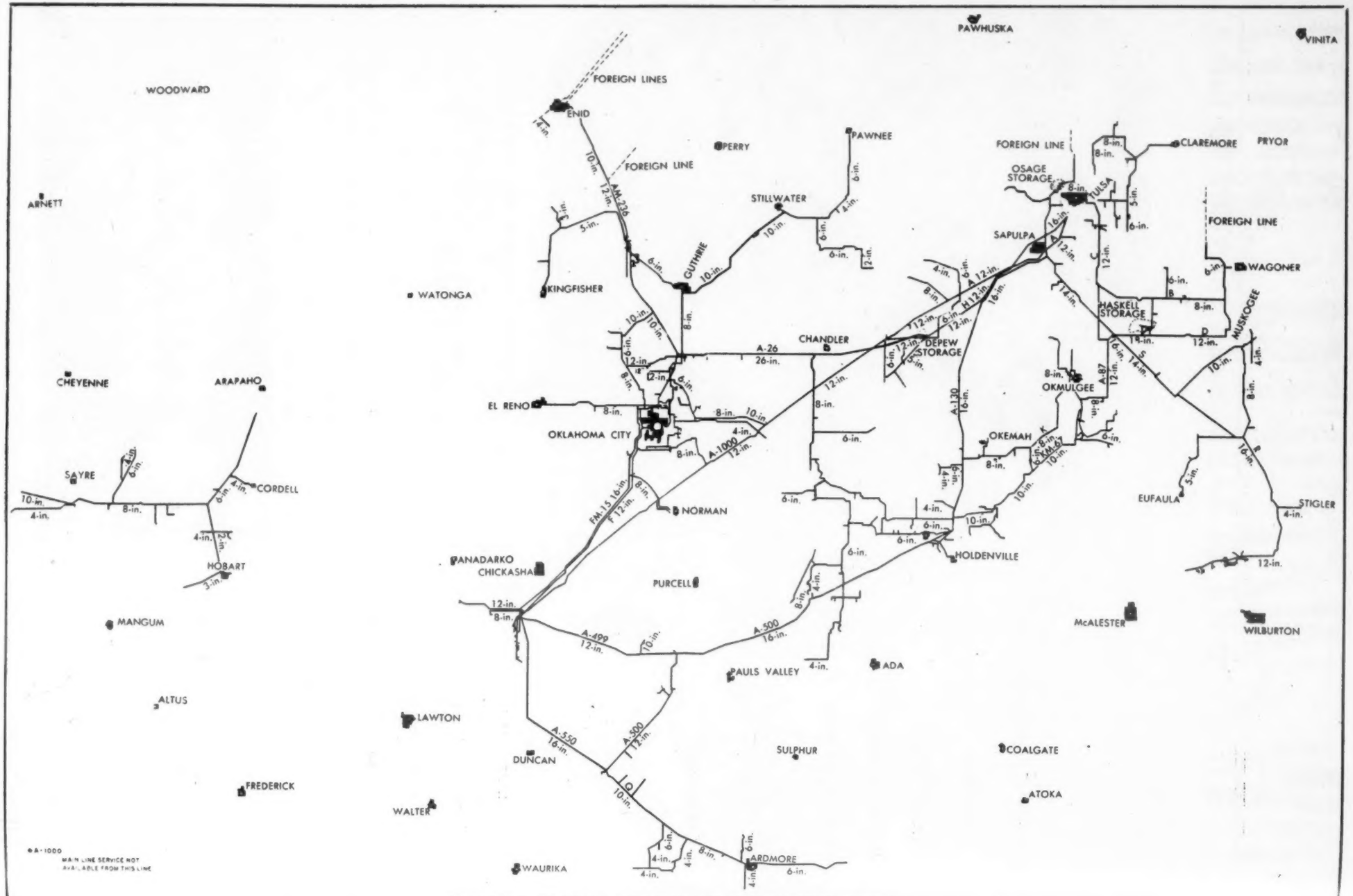
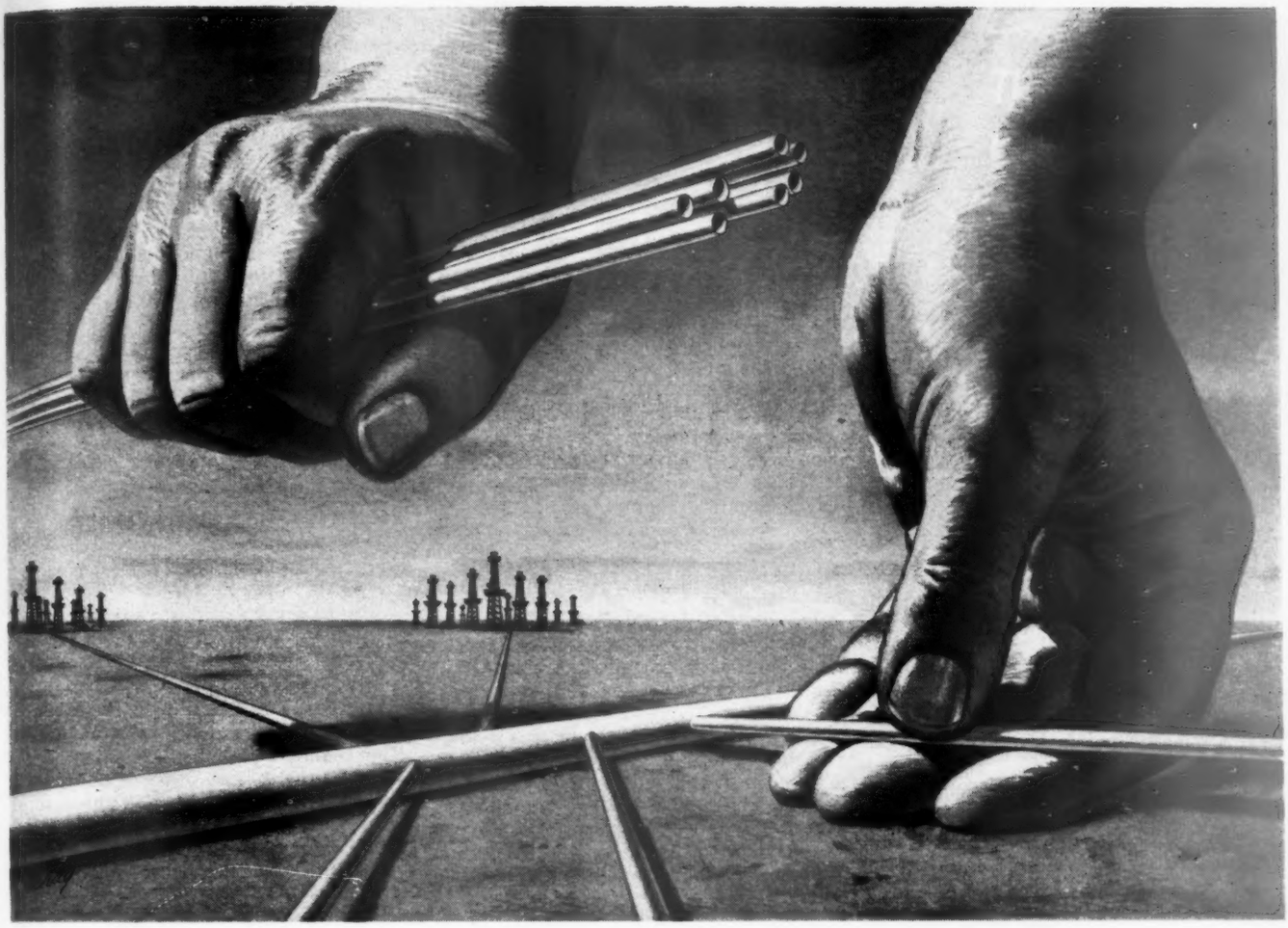


OKLAHOMA NATURAL GAS COMPANY TRANSMISSION SYSTEM.



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Continuous Weld—Plain End	2⅜" to 4½" O.D.	Up to 40'	Standard	Fontana, Calif.
Electric Resistance and Fusion Weld—Plain End	8⅝" to 20" O.D.	Up to 40'	.188" to .500"	Napa, Calif.—Basalt-Kaiser
Electric Resistance Weld—Plain End	5⅝" to 12¾" O.D.	Up to 55'	.188" to .375"	Fontana, Calif.
Electric Fusion Weld—Expanded—Plain End	22" to 30" O.D.	Up to 40'	.188" to .500"	Napa, Calif.—Basalt-Kaiser

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transmission superintendent has supervision over three crews, each composed of six men in charge of a foreman. Additionally, there are welders, welder's helpers, tractor driver, and ditching machine operators who operate on a roving assignment, by which is meant that they are attached to whatever crew needs them for their particular type of work.

Record System

As has been mentioned, an adequate system of records is an essential part of the program. The form for reporting on line maintenance is shown in Fig. 1. As can be seen, this form when filled in shows on what line the leak occurred and the district in which the line is located. It shows the location of the leak and the type, whether a pit, coupling, threads, etc., and the method employed to make the repair, whether band clamp, patch, collar leak clamp, etc., or whether it was found necessary to install a section of new pipe. If the latter was the case, a record is made of the pipe size, length replaced, general condition of the pipe, and how replaced (welded or coupled). In the lower left-hand corner of the reporting form is a place for a sketch of the line showing the section where the repair was made. To the right of this sketch, the name of the landowner is recorded, together with an estimate of the surface damage caused by the leak. A copy of the report is sent to the right-of-way department in the general office, which uses it to settle damage claims, a copy goes to the district superintendent, and a copy is kept by the district transmission superintendent. Indexed and filed, they provide a complete history of every line in the system.

In addition to maintaining a file, each district office also keeps an up-to-date map on repairs made in its area. By means of pins having different colored heads it is discernible instantly exactly what type of repair has been made at each location.

Procedures

Oklahoma Natural's system is patrolled entirely by linewalkers, this being considered the most advantageous method for its particular circumstances.

When a blowout occurs the line is taken out of service, if at all possible, the damaged pipe replaced, and the entire section tested hydrostatically. In this way any other leaks or weaknesses in the pipe can be ascertained and repaired while the line is not in use. The older lines are tested at a pressure not exceeding 600 psi. Prior to making the test, customer meters are turned off. If there are low rated valves, cast-iron saddles, or any other low rated equipment on the section of line, such equipment is replaced before the test is made. Some of the very old lines, incidentally, are operated at pressures as low as 350 psi and at a maximum of 525 psi. Lines installed within the last 10 or 15 years, however, were designed for a working pressure of 800 psi and higher.

It is considered good practice, also, to make certain hydrostatic tests even when there are no leaks; for instance, if the line is in a particularly corrosive or hazardous area, or if it is becoming of an age that there is possibility of impending failure. Here again is demonstrated the value of the record system, which reveals with very little research the condition of all lines at all times.

Fig. 2 is the form used in keeping the record for the water test. The form, when properly filled in, contains all essential facts in connection with the test and is filed for future reference.

Further in keeping with the idea of preventive maintenance is Oklahoma Natural's increasing emphasis on cathodic protection to obviate future repairs. Magnesium and carbon anodes and rectifiers have been installed extensively throughout the system and tests are being made constantly to determine corrosive areas where additional protection is needed. The company also has established a training school to provide for each district the necessary technicians to maintain and service the cathodic protection of the system.

Station Maintenance

Oklahoma Natural's system has three major stations, five transmission booster stations, and a number of Btu stabilization plants. The procedure and organization for the upkeep of these stations are somewhat different than in the case of line maintenance. Supervising the heavy maintenance of the entire group is the superintendent of compressor stations who makes his headquarters in the general office at Tulsa. Each chief operator and his regular operators have light maintenance as a part of their duties in addition to operating the station. There is, however, a crew of four that does the heavier maintenance work. This may be on emergency call, but in any event the crew visits each station periodically for the purpose of overhauling the engines. These visits are based primarily upon the chief operators' reports and the daily tour reports of the regular operators, which include such data as oil consumption, temperatures, etc., indicating the need or lack of need for a general overhaul. The superintendent of compressor stations is kept closely advised in this manner of conditions at each station and enhances such knowledge by frequent visits to the stations and close personal contacts with those in charge.

The operational base, so to speak, for maintenance and transportation of the entire system is at Oklahoma City, where a general machine shop and garage are maintained. At this machine shop major repairs are made to equipment. Shops for minor repairs are provided in the various districts, and for parts and supplies generally there is a warehouse in each district headquarters, as well as in other strategically situated smaller towns. ★ ★ ★

☆ ☆ ☆

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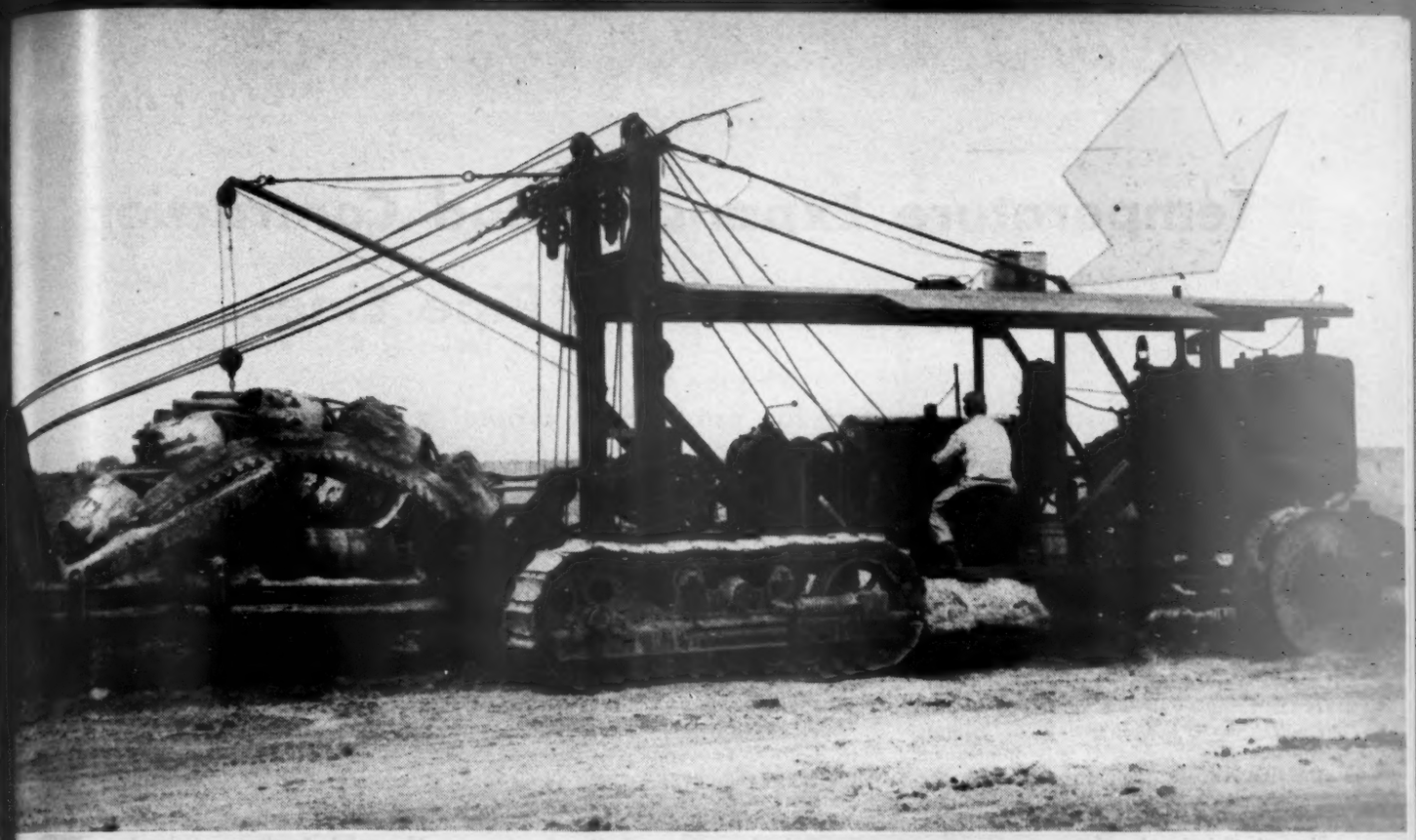

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Temperature Expansion and Contraction Stresses in Buried Pipe Lines

Procedure suggested for establishing proper soil restraint to minimize compressive and tensile stresses in welded hot-oil systems

FRITZ KARGE*

A pipe line resting on earth or supports will expand in accordance with well known physical laws when the temperature of its steel is increased by the application of heat externally or through the liquid in the line. If only one end of the line is to be anchored so that it will not move, the anchor must be capable of resisting a force somewhat larger than the frictional resistance on its supports of the combined weight of the pipe line and its contents, assuming a level profile for the line. If the pipe line is to be anchored at both ends, the anchors must be strong enough to resist the full expansive force of the pipe, this force being the same whether the line is one inch or thousands of feet long, as shown in the following formula:

$F = E \times e \times Td \times A$, in which the length of the line is not a factor and in which:

F = force,
E = modulus of elasticity (for mean temperature),
e = coefficient of expansion (for mean temperature),
Td = difference between initial and final temperature,
A = cross section area of steel in pipe.

Anchoring a long pipe line only at its ends does not keep it in alignment. It will buckle sideways because it is not strong enough as a column to resist the high compressive force developed through expansion. Such a pipe line, however, can be kept in alignment by fastening it to relatively small anchors spaced at such intervals that the pipe between two successive anchors is strong enough as a column to stand the compressive force without buckling. The anchors also will restrain longitudinal expansion of the pipe line, the magnitude of the restraint depending on the construction of the anchors.

The following formula evaluates the restraining effect of such anchors:

$$\frac{F}{R} = N$$

In which:

F = expansion force,
R = magnitude of restraint of one anchor,
N = number of anchors,
L = N times spacing of anchors, in ft.

If a free end pipe line restrained along its whole length by small anchors, is at least twice as long as L, each half of the line will expand in the direction toward the free end one-half as much as the pipe would expand for distance L if not restrained by anchors. This is so because the first anchor from a free end offers little restraint, whereas at the last anchor on the inner end of distance L the cumulative effect of all anchors in the section is fully developed. The total value of the anchors, therefore, is one-half of $R \times N$, so far as expansion movement of the pipe is concerned. An additional section of pipe between two L sections, whether one or thousands of feet long, is completely restrained and will not expand. If the free end is to be prevented from moving, an anchor must be provided strong enough to resist the entire expansive force. As previously pointed out, the expansive force is the same whether the expanding pipe is long or short.

The definition of L will be used repeatedly in other parts of this discussion.

Long stretches of welded railroad rails constitute an analogous case. The temperature of rails varies over wide limits, from freezing to sun heat. During the last 20 years, the practice of welding rails in straight sections for thousands of feet has increased. They are kept from buckling and expanding by the restraint offered by the ties to which the rails are fastened, the ties, in turn, being restrained by ballast and road bed. Expansion must be taken care of only and definitely at discontinuities, that is, at the ends of welded sections.

Buried pipe lines are restrained in the trench by friction against the earth surrounding it. The amount of restraint per foot of pipe depends on the size of the line, the depth of cover, the character and density of the backfill, the roughness of the pipe or coating surface, and on the manner in which the backfill was made. A well-compacted backfill will offer higher restraint values than one of loosely dumped earth.

The question is: What value can be assigned to the restraint offered by the soil surrounding the pipe?

The *Oil and Gas Journal* of March 22, 1951, contains the article "Slack in Buried Gas Pipe Lines" by G. M. McClure and L. R. Jackson of the Battelle Memorial Institute, Columbus, Ohio. This institute was employed by Texas Eastern Transmission Corporation to determine, for its 20-in. gas line, longitudinal residual stresses due to temperature variations during the construction of the line. The value of soil restraint was also determined in 17 locations and found to vary from 47 lb per sq ft of pipe surface to 1080 lb. The article states that these values are not absolutely accurate and that they appear to be independent of soil conditions. No attempt is made to account for the wide spread, but the summary statement is made that the restraint required by pipe lines is lower than the potential restraint any soil can offer.

In the following the restraining effect of the earth is calculated for an 18-in. pipe line, having 5/16-in. wall thickness, using the formula of Dean Marston of Iowa State College, Ames, Iowa, bulletins 31 and 96. This formula has been accepted universally as giving reliable results. The theoretical basis of the formula and its confirmation by many tests is also given on page 1063 et sequ. of Crocker, *Piping Handbook*.

$$W = CW B,^2$$

In which:

W = load on pipe in ditch, pounds per linear foot,
C = coefficient based on ratio of height of fill at top of pipe to breadth of ditch a short distance below the top of pipe, $\frac{H}{B}$
w = weight of ditch filling earth, pounds per cubic foot, usually 100 to 130.

For the case under consideration:

$$\frac{H}{B} = \frac{30 \text{ in.}}{18 \text{ in.} + 12 \text{ in.}} = 1$$

*Consulting Engineer, 452 Mendoza Terrace, Corona Del Mar, California, formerly Chief Engineer, Pipe Line Department, Union Oil Company of California.

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C = 0.85, Table IX, page 1066 *Piping Handbook*

$W = 0.85 \times 100 \times 2.5^2 = 531$ lb

Weight of 18-in. × 5/16-in. pipe = 59 lb

Weight of liquid 100 lb

Weight of full pipe on bottom of ditch 690 lb per ft of pipe.

If the soil on both sides of the pipe is compacted, passive pressure of soil against pipe will be established. Karl Terzaghi, well known soil specialist, shows that this pressure will amount to from 0.2 to 0.8 of the weight of earth above the horizontal center of the pipe.

Height of earth: 30 in. + 9 in. = 3.25 ft.

Passive pressure with factor of 0.2 = $3.25 \times 100 \times 2 \times 0.2 = 130$ lb per ft of pipe.

Assuming a friction factor of 0.4 between pipe and earth, the total restraining effect is $0.4 \times (690 + 130) = 328$ lb per linear foot of pipe.

The pipe circumference is 4.7 ft, giving a restraining effect of $\frac{328}{4.7} = 70$ lb per square foot of pipe surface, 18-in. pipe.

This value will decrease with soil weighing less than 100 lb per cubic foot and increase with heavier soil. The friction factor probably will be higher than 0.4 if the pipe coating has a rough surface. Compacting of the soil on both sides of the pipe would probably raise the restraint value. A wider trench will increase the load on the pipe and the restraint value.

Trenton Dames, of Dames and Moore, Los Angeles, consulting foundation engineers, recently calculated frictional soil restraint on pipe by an analysis of his own. He gives the following values:

In wet mud — 10 lb per sq ft minimum.

Sand — 50 lb per sq ft minimum for submerged sand.

Sand and clay — 50 to 300 lb per sq ft, not submerged.

Pipe lines usually are laid with some slack, in long, gentle bends, the pipe axis meandering from one side of the trench's center line to the other. Due to the slackness of the pipe, residual stresses caused by large differences in temperature while installing successive sections of the line tend to neutralize so long as the backfill has not been made. After the trench has been backfilled, such balancing of residual stresses ceases, as it requires high tensile or compressive forces to alter the shape of the gentle bends against the pressure of the earth on the sides of the pipe. Conversely, these bends increase the restraint against axial expansion or compression of the pipe. Any curves in the alignment of the pipe line, whether gentle or sharp, will anchor the pipe in a shorter distance than L in a straight section. The restraint value also will increase with time because of additional compaction of the backfill by rain.

> If all the wells drilled in the search for oil and gas in the U. S. in the last eight years were laid end to end, they would reach all the way through the earth and out into space more than half way to the moon.

Summing up these preceding calculations and considerations, it seems entirely rational to assume a restraint value for 18-in. pipe of 300 lb per linear foot, or 64 lb per square foot of pipe surface.

Assuming a pumping temperature for this 18-in. pipe line of 190 F, and further assuming that it was buried when the steel was at a temperature of 90 F, the expansive force will be 19,625 psi of steel and the total force 19,625 × 17.36 sq in., or 340,000 psi. L would then become $\frac{340{,}000}{300} = 1130$ ft.

At a "free" end, like a 90-deg bend, the expansion movement, if expansion is resisted only by the frictional restraint of the earth would become

$$\frac{1130 \times 100 \times 0.0000068}{2} = 0.38 \text{ ft or } 4.56 \text{ in.}$$

If the pipe continues in a reasonably straight line beyond the first 1130 ft from the free end, it will be completely restrained for a temperature rise of 100 F, from 90 F, until at another bend, or free end of another kind, expansion again occurs for length L of 1130 ft, if it can be assumed that the whole section was buried in the same kind of soil, to uniform depth, and that the backfill was compacted.

Actually the bend, if buried but not otherwise anchored, will move, compressing the earth in the direction of movement. A relatively small movement, the smaller the better the backfill on the side of the pipe, will compress the earth to such firmness that further movement will become improbable. In other words, bend and earth become anchor.

That such self-anchoring takes place has been proved by carefully excavating hot oil lines at 90-deg bends situated at the ends of long straight sections of line. In some cases, when the line was in expanded position, 1½-in. to 2½-in. wide free spaces were found on the concave side of the bend. The theoretical free expansion in one case would have been 6.8 ft. In other cases, the earth on the concave side was loose, and quite firm on the convex side of the bend. From the amount of movement that measurably took place, the length of the L section was calculated by assuming that the measured movement, arrested by compaction of the earth ahead of the bend, was one-half the theoretical movement at a "free" end. As previously shown, the theoretical expansion of the "free" end L section, in turn, is one-half as much as that that would take place if the section was neither restrained by earth in a trench nor by small anchors spaced

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along the line. From the calculated length of the L section, the restraining effect of the earth was found to have been from 57 to 96 lb per sq ft of pipe surface, mostly in dry sand, as against 64 lb per sq ft of surface as assumed for the 18-in. pipe.

Pipe lines are known to have been pushed upward and out of the soil. This will happen only when the line is laid in a very shallow trench, resulting in little earth restraint, and in a long L section, and where the profile of the route reached a high point, requiring a bend in the pipe with the convex side on top of the pipe.

As the oil cools in the direction of flow, the expansive force decreases, so does the length of L and the expansion movement at free ends. Actually, the expansive force is reduced by the tension in the line caused by line pressure. These tensile stresses probably amount to 30 per cent of the circumferential hoop stresses. Even if these tensile stresses are not considered, the soil restraint is sufficient to prevent large longitudinal movements of the line if the line is not buried in soft mud and if the backfill has been compacted.

Returning to the 18-in. pipe line. After the line has been in use at a pumping temperature of 190 F, it will take several days for oil and steel to cool to ground temperature after a shut down. Any free end L sections will contract. The pipe between such sections will remain stationary. The compressive stresses, however, will reduce to zero when the steel has cooled to its installation temperature and change to tensile stress if the line cools to still lower temperature.

Pipe lines have pulled apart under such conditions, usually at poor welds or at improperly installed collars.

It is well known that well-made welds are as strong as the pipe. Inspection and test methods have been developed that eliminate poor welding and the possibility of pipe lines pulling apart when contracting in cold weather.

Hot-oil pipe lines usually are designed to have their maximum capacity during the coldest and wettest winter conditions, when the temperature of the flowing oil drops more rapidly than in summer. During the warmer seasons the pipe line will then move the oil at maximum capacity with lower temperature and pressure.

The compressive and tensile stresses in a pipe line can be limited to relatively low values if the backfill over the line is made and soil restraint established when the pipe steel is at a temperature approximately midway between the lowest ground temperature and the highest temperature of the flowing oil, both for winter conditions. The fact must be kept in mind that the oil temperature at the discharge end of a line will be lower than at the pumps. The important issue is to establish soil restraint at a time when the pipe is at or near the midway temperature, provided the weather makes it possible.

It is assumed in this discussion that the section of line being buried on any day has been on the skids long enough, that is for at least one full change from early morning temperatures to full sun heat, to equalize the different states of expansion of sections welded during the coolest part of the day and others welded during the heat of the day.

Besides reducing compressive stresses, the procedure suggested above will have the following results: Assuming the same earth restraint value used in a previous part of this discussion, namely 300 lb per linear ft, of 18-in. pipe, the length of "L" will decrease and so will the expansion movement of a free end. Conversely, earth restraint of lesser values due to smaller weight of backfill earth, or due to other unfavorable conditions, will still give a length of "L" and free end expansion of acceptable values.

For better bedding of large pipe and increasing its resistance to flattening while empty, it is advisable to shape the bottom of the trench to the pipe. This probably can be done with the ditching machine without additional cost.

These suggestions were discussed with pipe line contractors and experienced inspectors and were considered entirely practicable.

It is hoped that this brief discussion answers the questions asked by engineers without experience with hot-oil buried pipe lines concerning the movements and stresses in such lines. ★★

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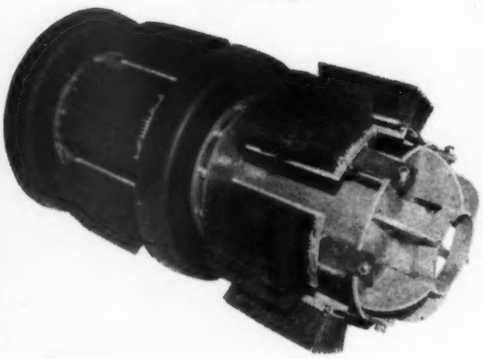

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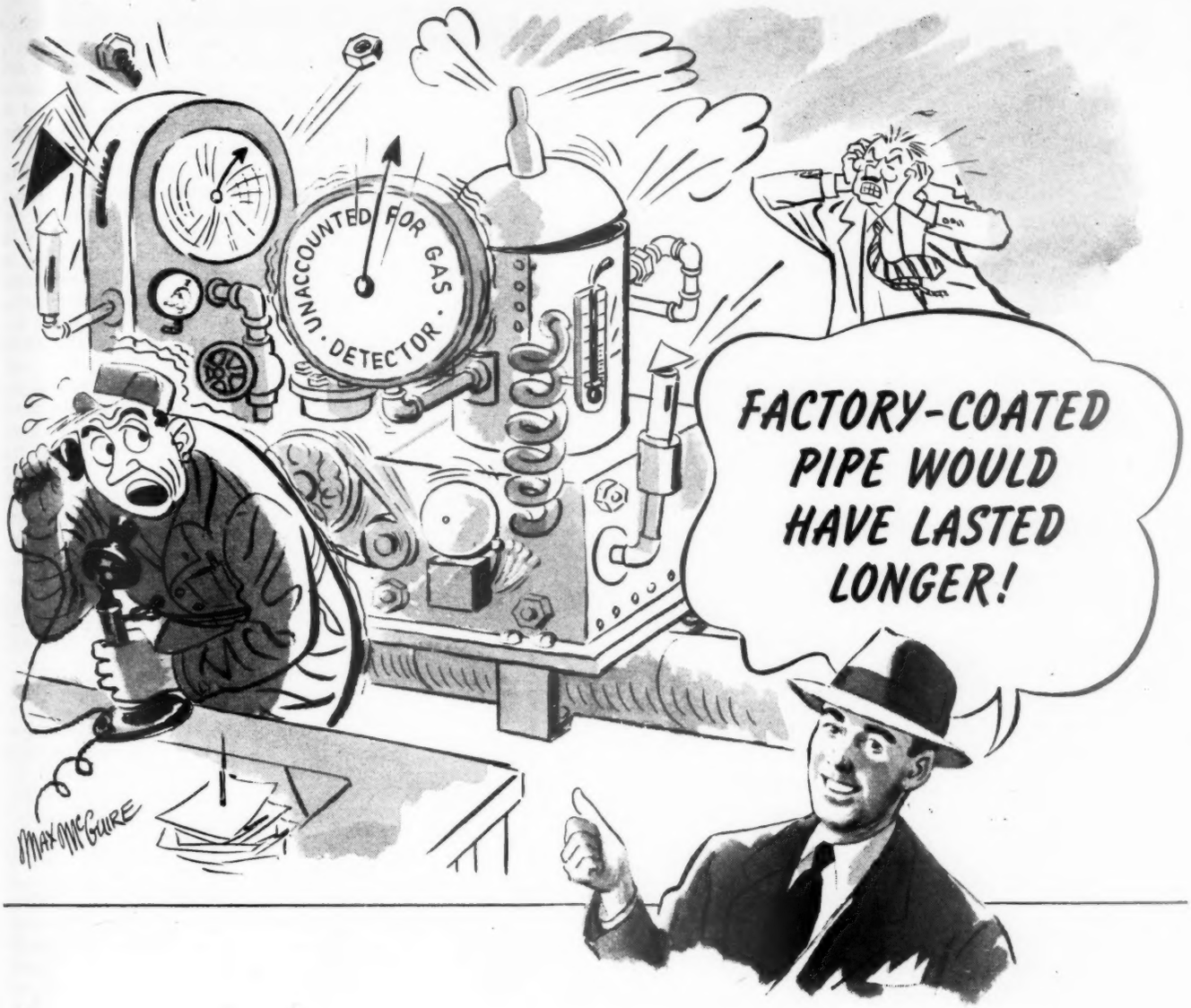

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Quarter Billion-Dollar Plans

FPC approves 1915 miles of pipe lines and 351,960 compressor horsepower in first half of 1952

NATURAL gas pipe line facilities that will add more than 1¼ billion cubic feet daily delivery capacity to the nation's individual transmission systems were authorized by the Federal Power Commission during the first six months of 1952, Chairman Thomas C. Buchanan announces.

The new facilities authorized during the first half of this year include 1915 miles of pipe lines and have an estimated total construction cost of $235,420,973.

Major projects—those estimated to cost $700,000 or more each—accounted for approximately $179,729,935 of the total construction cost. The major projects are expected to benefit 101 cities of 50,000 population or over in 25 states and the District of Columbia, as well as numerous small communities.

These larger projects will increase the daily delivery capacity of the individual pipe line systems involved by nearly 1,100,000,000 cu ft of natural gas a day, and involve construction of approximately 1410 miles of new pipe line and installation of compressor facilities aggregating 351,960 hp.

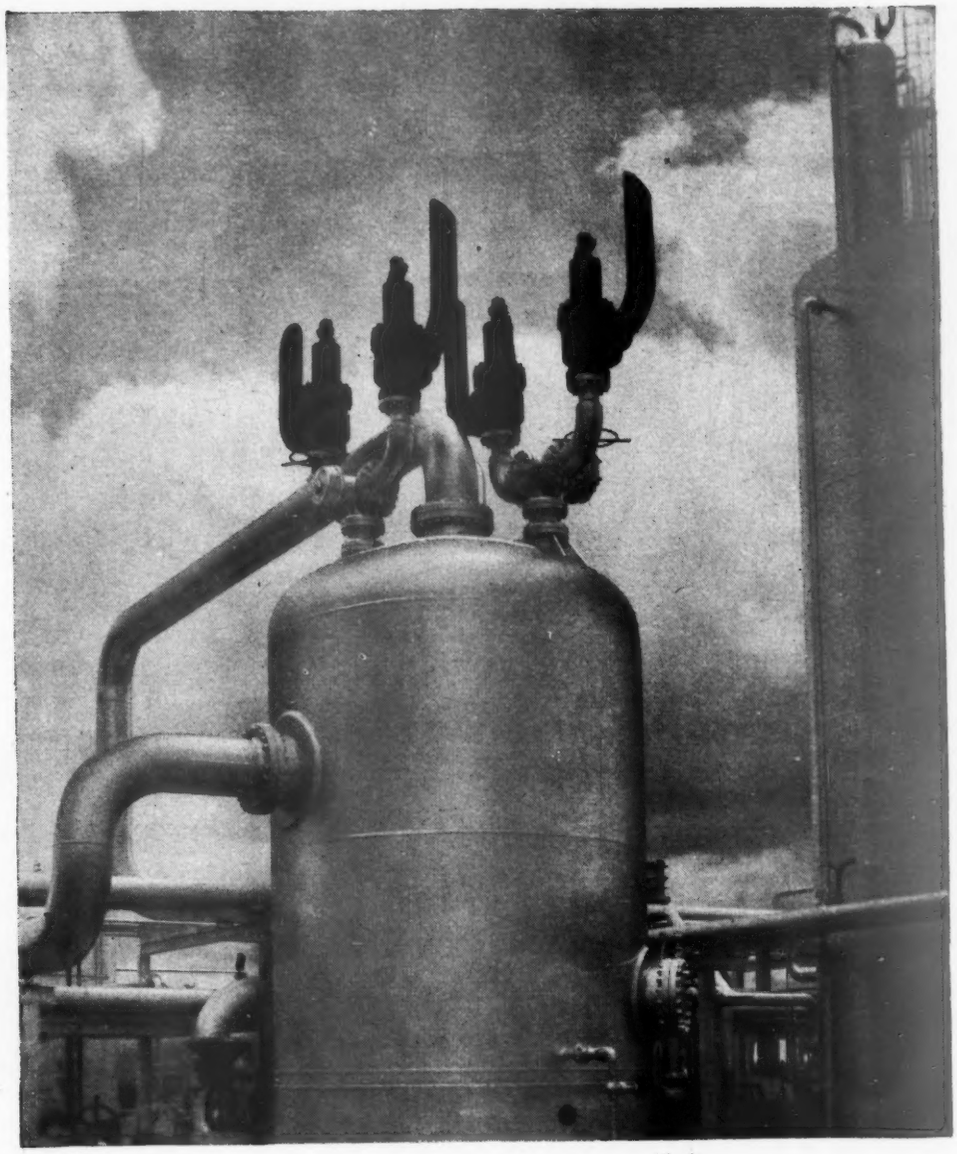
During the 6-month period, the largest single authorization was for Tennessee Gas Transmission Company to construct and operate 591 miles of 24, 26, and 30-in. parallel loop lines along its existing system; a 304-mile 24-in. transmission line from Mercer, Pennsylvania, to Utica, New York; 250 miles of miscellaneous lateral lines, and 163,000 hp in new, existing, or authorized compressor stations. This construction project is estimated to cost $128,216,000, and is designed to increase Tennessee's delivery capacity by 205,000,000 cu ft a day to provide additional service to existing customers particularly in New York state and the New England area with minor increases to main line customers in Tennessee and Kentucky. These facilities also will be used in connection with an underground storage project in Pennsylvania being developed jointly by Tennessee and United Natural Gas Company.

The commission during the fiscal year ending June 30, 1952, authorized construction of a total of 3378 miles of pipe line and installation of compressor units aggregating 539,510 hp at a total estimated cost of $321,919,895. Major projects costing $700,000 or more authorized during this 12-month period had a total estimated construction cost of $255,588,038 and included 2449 miles of pipe line and installation of 430,990 hp in compressor units. These facilities are designed to add more than 1,500,000,000 (billion) cu ft a day delivery capacity to the Nation's individual pipe line systems.

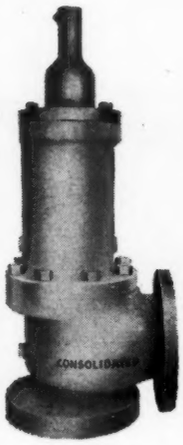
Since February 7, 1942 (the date when the present certificate provisions of the Natural Gas Act became effective), the FPC has authorized a total of nearly 45,800 miles of pipe line and 3,300,000 hp compressor units at a total estimated cost of nearly $3,200,000,000. The facilities authorized since 1942 are designed to add more than 17,000,000,000 cu ft a day delivery capacity to the Nation's individual pipe line systems.

Chairman Buchanan noted that although the construction authorized by the FPC in the first six months of 1952 will increase the daily delivery capacity of the individual systems by more than 1,000,000,000 cu ft, the amount of additional natural gas actually to be delivered to the Nation's markets will be somewhat lower. He said that this is because in some cases the same gas will be transported through the new facilities of two or more different utility companies. As an example, he noted that El Paso Natural Gas Company was authorized to expand the capacity of its system by 320,000,000 cu ft a day and will deliver that amount to Pacific Gas and Electric Company, Southern California Gas Company, and others on the west coast, which will further transport the gas by facilities that were authorized during the same 6-month period. ★ ★ ★

Applicant	Description of construction	Estimated cost
Cumberland and Alleghany Gas and Manufacturers Light and Heat	Construction and operation of 51 miles of 4-inch to 10-inch miscellaneous pipe lines and a 2080 hp compressor station in Mountain Lake Park field, Garret County, Maryland.	$2,197,637
Colorado Interstate Gas Company	Construction and operation of 48 miles of 20-in loop pipe line on Denver, Colorado line, 22 miles of 6⅝-in. laterals in Denver area, and 7080 hp additions in compressor stations in Texas and Colorado.	$3,379,532
New York State Natural Gas Corporation	Construction and operation of 66 miles of 20-in. loop pipe line in Pennsylvania, 17 miles of 16-in. loop line in New York 22 miles of 14-in. replacement pipe lines, and 1820 hp additions in compressor units on system.	$6,018,900
United Gas Pipe Line	Construction and operation of 11 miles of 20-in. pipe line to connect Turtle Bayou and Kent Bayou gas fields in Louisiana to applicant's system.	$1,461,000
The Ohio Fuel Gas	Construction and operation of 31 miles of 20-in. transmission pipe line from Treat compressor station to Weaver gas storage pool in Ohio.	$1,440,000
Washington Gas Light	Construction and operation of a storage project consisting of 21 miles of 24-in. pipe line segments and a 4800 hp compressor station near Rockville, Maryland.	$6,820,000
Lone Star Gas	Construction and operation of 70 miles of 20-in. transmission line from Garvin County, Oklahoma, to Petrolia (Texas) compressor station.	$2,799,400
United Gas Pipe Line	Construction and operation of 36 miles of 20-in. to 26-in. transmission lines from Mustang Island (Red Fish Bay) field near Ingleside, Texas, to applicant's Refugio, Texas, compressor station.	$2,735,000
Cities Service Gas	Construction and operation of 15 miles of 20-in. replacement line connection with Graham compressor station, Kansas, and additions to Welch, Oklahoma and Pierce City, Missouri compressor stations of 1360 hp.	$811,800
Cities Service Gas	Construction and operation of 21 miles of 26-in. pipe line to replace smaller lines in Franklin County, Kansas, and a 1000 hp addition to Welda compressor station in Kansas.	$1,378,500
Amere Gas Utilities Company	Construction and operation of 32 miles of 8⅝-in. and 2 miles of 3½-in. miscellaneous lines on system in West Virginia.	$802,340
Chicago District Pipeline Company	Construction and operation of 12 miles of 30-in. connecting pipe line with Texas-Illinois Natural Gas Pipeline Company near Elgin, Illinois, to facilities of Public Service Company of Northern Illinois.	$1,650,000
Tennessee Gas Transmission Company	Construction and operation of 591 miles of 24-in., 26-in., and 30-in. parallel loop lines along existing system, 304 miles of 24-in. transmission line from Mercer, Pennsylvania area to a point near Utica, New York; 137,000 hp in existing or authorized compressor stations and 28,000 hp in new stations, and 250 miles of miscellaneous lateral lines.	$128,216,000
El Paso Natural Gas Company	Construction and operation of 37 miles of 24-in. loop lines in Arizona, 34 miles of field lines in New Mexico, and 46,640 hp in new and additions to existing stations in New Mexico and Arizona.	$26,050,000
El Paso Natural Gas Company	Construction and operation of 143 miles of 28-in. and 30-in. loop lines on main system, 295 miles of miscellaneous 6-in. to 30-in. field lines in Texas and 153,960 hp additions to existing and new Main line, field and booster compressor stations in Texas, New Mexico, and Arizona.	$62,695,000
Pacific Gas and Electric Company	Construction and operation of 86 miles of 34-in. loop lines in segments on Topock-Milpitas line in Arizona and California, and 19,540 hp additions in existing main line compressor stations.	$13,428,000
Nevada Natural Gas Pipe Line Company	Construction and operation of 114 miles of 10¾-in. transmission line from a connection with El Paso Natural Gas Company near Topock, Arizona, to Las Vegas, Nevada.	$2,319,140
Southern California Gas Company and Southern Counties Gas Company of California	Construction and operation of 20 miles of 30-in. loop line in California and additions to existing compressor stations of 13,520 hp.	$5,053,686
Northern Natural Gas Company	Construction and operation of 213 miles of 26-in. loop line on main line in Kansas, Nebraska, and Minnesota and compressor stations aggregating 100,160 hp in Texas, Kansas, Nebraska, and Iowa.	$38,690,000



Consolidated Safety Relief Valves installed on main scrubber at Stanolind Oil & Gas Co., Stano, Kansas.



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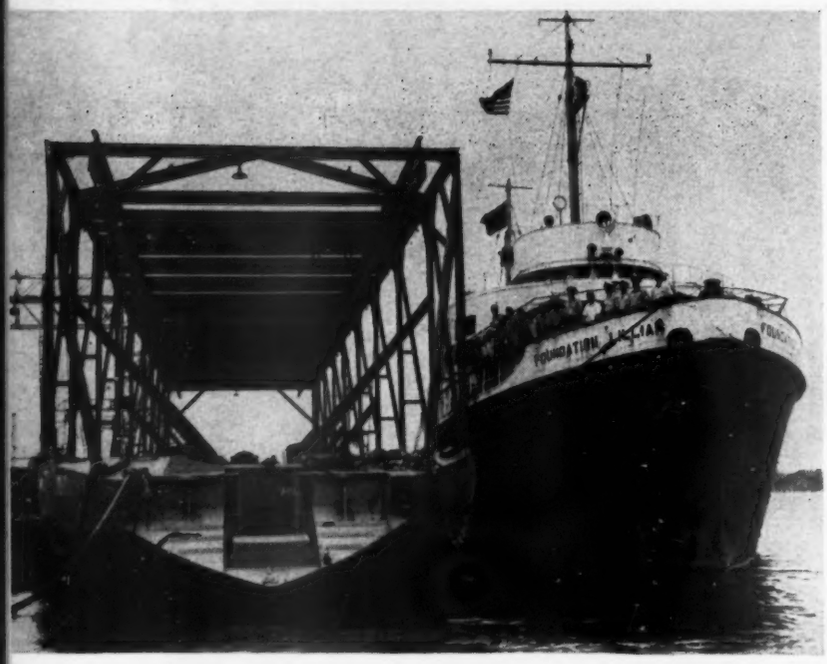
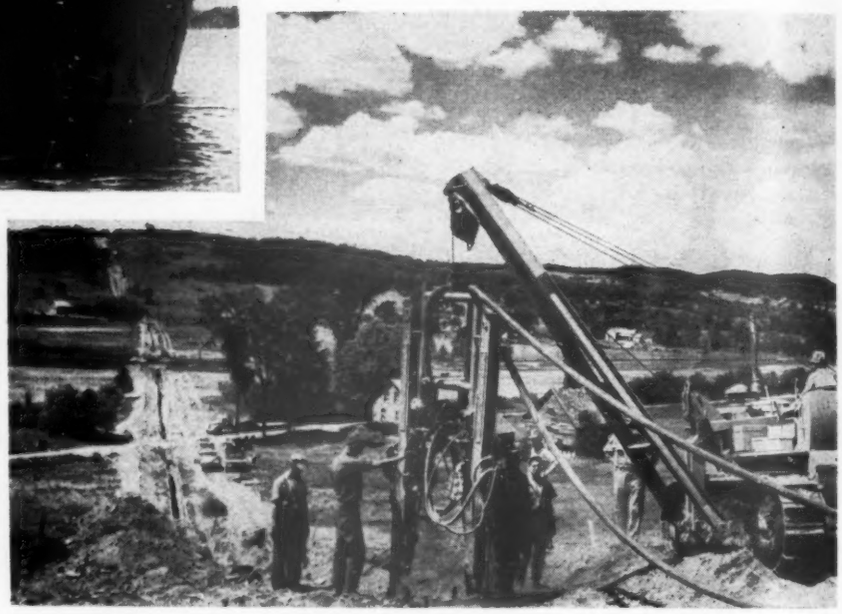


In conjunction with the Gulf of Coro marine crossing, now under construction by Anderson Brothers of Venezuela, C. A., for the Creole Petroleum Corporation, the 195-ft pipe laying barge shown above recently left Port Arthur, Texas, for Las Piedras, Venezuela. This 26-in. line, 80,000 ft long, will be laid on the bottom of the Gulf of Coro. Anderson-Gibbs Corporation, the Marine Division of Anderson Brothers Corporation, is laying this line and about six months will be required for completion. L. C. Gibbs, president of Anderson-Gibbs, is on the job site.

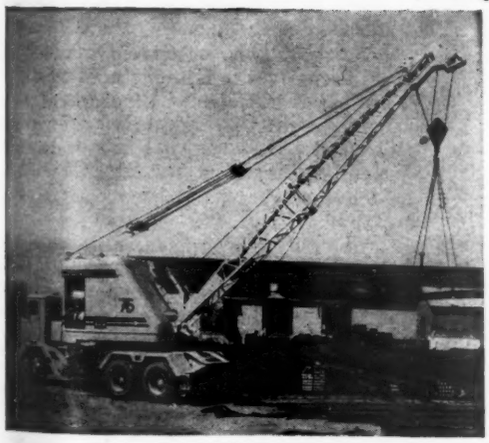
Caterpillar Diesel D7 tractor with sideboom cradles a wagon drill on pipe line construction of Sparling-Davis Company in Canada.



The welding gang on H. C. Price Company's Spread One stretches out over several hundred feet of 26-in. pipe being laid in South Central Ohio for the Tennessee Gas Transmission Company.

New GarWood Shovels

¾ yd. Shovels, Cranes, and Truck Cranes!



Gar Wood's new shovel line includes 3 base machines, the 75A standard-duty ¾ yd., the 75B heavy-duty ¾ yd. and the 75BT, 20 ton truck crane . . . All models can be easily converted *in the field* for shovel, lift crane, clam, dragline, magnet, trench-hoe and pile driver work . . . *Only* GAR WOOD offers the new *Foundation Borer*—an attachment that opens a new source of profit to power excavator operators! . . . GAR WOOD design combines such features as Instant Manual Controls; Power Actuated Drum Clutches; Dual Right Angle Drive; Fluid Couplings; Independent Chain Crowd plus many others . . . Check your GAR WOOD shovel distributor for complete information on the entire line!

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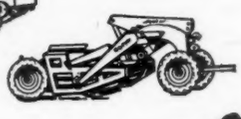

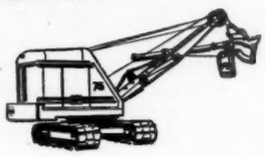

Gar Wood construction equipment includes 12 new TipDozers and Dozecasters, both hydraulic and cable controlled, for use with all models of Allis-Chalmers tractors . . . Big, tractor-drawn scrapers work smoothly and efficiently on both large and small earthmoving jobs . . . The new "75" series, ¾ yd. Gar Wood shovels and famous "Buckeye" Ditchers are useful on any job!

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Construction Equipment: Excavators, Scrapers, Dozers, Ditchers, Spreaders, Finegraders, Truck-mounted Road Graders. Truck Equipment: Dump Truck Bodies & Hoists, Winches & Cranes, Refuse Collection Bodies, Elevating End Gates.

Pipe Line Personals

Robert D. Brunet of White Plains, New York, a gas engineer for Columbia Gas System Service Corporation, has been made assistant to the president of the Charleston Group. A native of Providence, Rhode Island, Brunet was graduated from Cornell University in 1941 with a BS degree in engineering. After 4½ years in the navy he joined the staff of the Mississippi River Fuel Corporation at St. Louis, Missouri, as an engineer. Since 1949 he has been with Columbia Gas System. He will have his headquarters at Charleston, West Virginia.

Glenn E. Nielson of Cody, Wyoming has been elected to the board of directors of Northern Natural Gas Company. Nielson is president of the Husky Oil Company and of Husky Oil and Refining, Ltd., in Canada. He is also chairman of the board of directors of Gate City Steel Works, Inc., in Omaha. He has served twice as president of the Rocky Mountain Oil and Gas Association, and is a member of the National Petroleum Council.

J. L. Callahan

J. L. (J'm) Callahan has been promoted to utilities engineer for the Service Pipe Line Company, **A. H. Newberg,** chief engineer, announces. He will have charge of all contract negotiations with utility companies serving the company and will maintain headquarters in Tulsa, Oklahoma.

An electrical engineer, Callahan received his BS degree in electrical engineering from Oklahoma University in 1932. After graduation he worked for electrical supply houses in Tulsa and Muskogee, Oklahoma, before joining Shell Oil Company in 1934. During the next 12 years he worked as an engineer for Shell, Oklahoma Gas and Electric Company, and Phillips Petroleum Company.

He joined the engineering department of Service Pipe Line Company in November, 1946, and aided in planning and designing several of the company's pump stations.

Callahan is a registered professional engineer in Oklahoma and a member of the Tulsa chapters of AIEE and PIEA.

E. J. Wacker, who has been acting division superintendent of Magnolia Pipe Line Company's Southern Division with headquarters in Houston, Texas, has been made an assistant chief mechanical engineer and has been transferred to the company's general offices in Dallas.

J. R. Wright, district superintendent of Magnolia Pipe Line Company's Houston and Beaumont districts with headquarters in Houston, has been promoted to assistant superintendent of the company's Southern Division with headquarters at Houston.

L. J. White, formerly assistant district superintendent of the Dallas pipe line district with headquarters at Corsicana, Texas, has been promoted to district superintendent of the Houston and Beaumont district with headquarters at Beaumont, Texas.

M. R. Anderson, who has been chief engineer at Magnolia Pipe Line Company's Hebert station near Beaumont, has been made assistant district superintendent of the Dallas pipe line district with headquarters at Corsicana.

Wayne Harris, formerly assistant chief engineer at Corsicana, has been made chief engineer at Magnolia Pipe Line Company's Hebert station at Beaumont.

B. B. Balke, who has been chief gager of Magnolia Pipe Line Company's Northern Division, has been promoted to assistant district superintendent of the Healdton District.

Elmer E. Adams, formerly gager foreman at Maud, Oklahoma, has been promoted to chief gager of the Northern Division with headquarters at Healdton, Oklahoma.

A. T. Pasche, assistant mechanical engineer in Magnolia Pipe Line Company's general offices in Dallas, has been transferred to the Western Division as assistant mechanical engineer with headquarters at Midland, Texas.

B. G. Christopher, formerly junior mechanical engineer, has been promoted to assistant mechanical engineer and moved from the Telephone and Telegraph Department to the Mechanical Engineering Department, Dallas general offices.

D. H. Handley, who has been junior mechanical engineer, has been promoted to assistant mechanical engineer and transferred from the Telephone and Telegraph Department to the Healdton Pipe Line District.

R. C. Davidson, formerly assistant construction foreman in East Texas, has been promoted to construction foreman with headquarters at Corsicana, Texas, of Magnolia Pipe Line.

P. C. Culpepper, truck driver in Magnolia Pipe Line Company's East Texas District, has been promoted to assistant construction foreman in the company's East Texas District with headquarters at Greggton, Texas.

Charles A. Schrader

Charles A. Schrader, who at 37 is one of the youngest executives in the oil business in Michigan, has been elected president of the Michigan-Ohio Pipeline Corporation, which owns and operates the famous pipe line that "runs backwards" from Toledo, Ohio, into central Michigan.

Schrader had been vice president and general manager of Michigan-Ohio Pipeline Corporation since September, 1950. Michigan-Ohio Pipeline is a wholly-owned subsidiary of Mid-West Refineries, Inc., whose large refinery at Alma is supplied by Michigan-Ohio Pipeline.

The pipe line, built in the oil-drilling boom in Michigan more than a decade ago, was designed to carry Michigan crude from the central-state area to Toledo for transmission through the nation's major pipe lines. After Michigan's oil-drilling industry began to dwindle, Mid-West Refineries acquired the pipe line to assure itself a constant source of crude from the nation's principal pipe lines.

Schrader, who is married and has two children, lives in Grand Rapids. He is a graduate of Calvin College there and, before becoming associated with Mid-West Refineries five years ago, he was secretary-treasurer of Light Metals Manufacturing Company at Grand Rapids.

In 1948 he was made assistant secretary and assistant treasurer of Mid-West. In 1950 he was made vice president and secretary and, in addition was named vice president and general manager of Michigan-Ohio Pipeline later the same year.

John E. Overbeck recently was elected an assistant vice president of Columbia Gas System Service Corporation. He has been associated with Columbia for 35 years. From 1916 to 1928 he was on the staff of the Ohio Fuel Gas Company, and since that time has been with the service organization. Prior to his recent promotion he was supervisory engineer in charge of the corporation's gas measuring department.

G. P. Jennings, chief engineer of the Products Transportation Section of Phillips Pipe Line Company, Bartlesville, Oklahoma, has been promoted to superintendent of operations. **D. A. Roach** is now in charge of the Engineering Section as chief engineer, serving crude oil and products pipe lines.

G. G. Billings, formerly assistant area manager at Cushing, Oklahoma, for Shell Pipe Line Corporation, is now area manager for West Texas. He has replaced **A. F. Terrill,** who resigned after 33 years' service with the company.

Billings will now make his headquarters at Colorado City, Texas, where he began his career with Shell in 1936 as an engineer. Two years later he moved to the Willard office as division engineer and then to St. Louis as engineer. In 1940 he was transferred to Houston, Texas, to become head office personnel representative. He was made West Texas area engineer in March, 1941. Later that year he was promoted to Healdton division superintendent. In March, 1942, he became assistant Mid-Continent area manager with headquarters at Cushing. He went to Venezuela on special assignment with Shell Caribbean Petroleum Company in 1950, returning August 20, 1952, to assume duties as West Texas area manager.

Terrill will move to Vancouver, British Columbia, about October 1 where he has accepted a position as general superintendent of Trans Mountain Oil Pipe Line Company. He joined Yarhola Pipe Line Company (now Shell Pipe Line Corporation) in 1919 at Belle, Missouri, as a gang hand. During the course of his career he has been oiler, station engineer, station chief engineer, training representative, assistant personnel manager, division superintendent, and area manager.

Carl Ikard has been appointed to the newly created post of superintendent of gathering in the Hugoton Pipeline Division of Northern Natural Gas Company. He will be in charge of well operations. **Charlie Anglin** continues as Hugoton division superintendent in charge of construction and maintenance of gathering and transmission lines and stations.

Ikard is a 20-year veteran. His continuous service began July 1, 1931, with Argus Natural Gas Company, Inc., a Northern Natural subsidiary operating in Garden City, Kansas. In 1943 he was transferred to the Northern Natural organization as a clerk at Bushton, Kansas. He has been assistant division superintendent at Hugoton since June 9, 1947.

Wilbur A. Thorpe, formerly assistant plant superintendent at Sneed is now superintendent at Olpe compressor station of Panhandle Eastern Pipe Line Company. He has been in the employ of Panhandle Eastern for 15 years and prior to his new assignment worked in a variety of compressor station jobs in production and gathering department.

R. W. Phillips has been promoted from chief engineer to assistant general manager of The Texas-Empire Pipe Line Company and Kaw Pipe Line Company. **D. B. Good,** who has been assistant chief engineer, is now chief engineer of the two companies. Both men have their headquarters in Tulsa, Oklahoma.

B. M. Moroney, Gulf Oil Company, Pipe Line Division, Tulsa, Oklahoma, has been transferred to the Gulf Canadian Pipe Line Company, an affiliate.

N. E. Woolf, division machinist for Service Pipe Line Company, has been promoted to area master mechanic, **F. M. Willenburg,** East Texas division manager, Fort Worth, announces. In his new capacity, Woolf will assist Willenburg and his staff in the installation and maintenance of pumping equipment in the East Texas division. The division extends from Houston to the Red River, north of Bowie, and as far west as Kent County. It is expanding steadily to serve new oil production in Knox, Haskell, Stonewall, and other west central Texas counties.

Woolf was born in Bowie and served as city engineer five years before joining Service Pipe Line Company in 1926. He started as a pipe fitter and in 1930 advanced to division machinist. He will have his headquarters at Fort Worth.

Lloyd W. Whitney, Service Pipe Line Company engineer, has been promoted to division engineer and assigned to the company's new operating area in North Dakota, **R. R. Strand,** division manager, announces. Whitney has lived in Casper for 18 months. His new headquarters will be Williston, North Dakota, where he will be in charge of the Service Pipe Line Company's expanding gathering system in the Tioga area, a part of the Wyoming division. The company now is connected to 29 leases in North Dakota.

A graduate mechanical engineer of Oklahoma A. and M. college at Stillwater, Whitney served five years with the U. S. Army engineers during World War II. He spent three years in the Persian Gulf area and in Italy.

Service Pipe Line Company constructed and placed in operation early this year a gathering system in the Beaver Lodge and the Tioga pools to become North Dakota's first crude oil pipe line operator.

Carl Mercer has been named gas measurement engineer with the Charleston Group, Charleston, West Virginia. His duties will include engineering work in the measurement and metering departments. He began work for United Fuel Gas Company in August, 1950, after his graduation from Marietta College, and for the last year has been serving as an engineer with the meter department.

Curtis Bradford has been named superintendent of the Southern Division of United Fuel Gas Company. He has been in the employ of United Fuel since 1940. His headquarters are at Huntington, West Virginia.

H. D. Solsbery, formerly training representative (acting) in the Mid-Continent area for Shell Pipe Line Corporation, has become acting Texas-Gulf area personnel representative, succeeding **F. L. Underwood,** who has been granted a leave of absence to affiliate himself with Trans Mountain Oil Pipe Line Company. The latter will return to Shell upon completion of Trans Mountain's construction work.

F. M. "Bud" Elder, station superintendent at Middleton, Tennessee, for Tennessee Gas Transmission Company, is now superintendent of the Batesville, Mississippi, station. He succeeds **Bill Hall,** who has been transferred to Hebron, Pennsylvania, to become superintendent of the new compressor station that is slated to be constructed there next spring. **Vaughn L. Geiser** is the new superintendent at Middleton. Formerly he was assistant superintendent at Greenville, Mississippi. **J. E. Franks, Jr.,** plant foreman at Greenville is now assistant superintendent there.

Arthur C. Swanson, division electrician, Galesburg, Illinois, has been promoted to telephone and telegraph supervisor by Service Pipe Line Company.

Charley V. Burns, junior engineer, Tulsa, Oklahoma, has been made oil movements engineer.

J. D. Behling, oil movements engineer, Tulsa, was recently promoted to planning engineer.

H. E. Ritch, chief engineer at United Gas Pipe Line Company's new McComb, Mississippi, compressor station, is the latest addition to the ranks of those who have attained 35 years' continuous service with the United Gas System. He began work in the drilling department of a predecessor company at Hunter, Louisiana. He has been stationed at McComb since February 1 of this year. Previously he had been chief engineer at Hattiesburg, Mississippi, station for about eight years.

PAD Allots 206,000 Tons Pipe for Oil Pipe Lines

Thirteen large crude oil pipe lines and 10 large petroleum products lines, with a total construction cost of $390,800,000, as well as a number of other oil pipe line projects, have been granted priorities assistance by the Petroleum Administration for Defense for purchase of 205,669 tons of line pipe during the fourth quarter, Deputy Administrator J. Ed Warren has announced.

Among the projects receiving priorities assistance for the first time are:

A 960-mile crude line from Wink, Texas, to Norwalk, California, with a capacity of 200,000 bbl a day, to be built by the West Coast Pipe Line Company at an estimated cost of $101,128,000;

A 1595-mile products line, with an initial capacity of 300,000 bbl a day, from Port Neches, Texas, to Newark, New Jersey, to be built by the United States Pipe Line Company at an estimated cost of $141,091,000;

A 196-mile products line, with a capacity of 96,000 bbl a day, from Port Arthur, Texas, to Baton Rouge, Louisiana (connecting with the Plantation Pipe Line), to be built by The Texas Pipe Line Company at an estimated cost of $12,900,000.

A summary of fourth quarter line pipe allotments for oil pipe lines follows:

	Total cost	Line pipe—tons: Total assistance required	Line pipe—tons: Authorized for 4th qtr. 1952
13 large crude lines	$172,975,000	414,398	97,471
10 large products lines	217,825,000	482,759	79,948
Total	$390,800,000		
Other small projects — crude, products, terminals, small construction, and MRO			28,250
Total		897,157	205,669

Details of the larger projects are given in the attached tabulation.

	Line pipe—tons: Total assistance req'd.	Line pipe—tons: Authorized for 4th qtr. 1952
Shell Pipe Line Company—"Rancho"..... 463 miles 24 in. from McCamey, to Houston, Texas. Initial capacity—209,000 bbl per day Estimated cost—$41,631,000 Estimated completion date—1st qtr. 1953	119,982	1,279
Interstate Oil Pipe Line Company..... Extend and increase capacity in South Louisiana, lay 55 mi. 16 in., 64 mi. 12 in., 17 mi. 6 in., 14 mi. 8 in., and 7 mi. 4 in. Capacity increase—45,000 bbl per day Estimated cost—$5,610,000 Estimated completion date—4th qtr. 1952	2,350	2,250
Interstate Oil Pipe Line Company..... Lay 101 miles 4 in. through 16 in., expand South Louisiana system, and increase capacity by 22,000 bbl per day Estimated cost—$4,000,000 Estimated completion date—1st qtr. 1953	8,861	6,526
West Coast Pipe Line Company..... 844 mi. of 24 in. and 116 mi. of 26 in. from Wink, Texas, to Norwalk, California. Initial capacity—200,000 bbl per day Estimated cost—$101,128,000 Estimated completion date—4th qtr. 1953	213,792	56,000
Pasotex Pipe Line Company..... Lay 200 mi. of 8 in. from Wink to El Paso, Texas. Capacity increase—11,500 bbl per day Estimated cost—$3,285,000 Estimated completion date—1st qtr. 1953	11,968	11,968
Magnolia Pipe Line Company..... 29.5 mi. 8 in. loop on line serving Pegasus and Parks Pools in Midland County, Texas. Capacity increase—24,000 bbl per day Estimated cost—$575,000 Estimated completion date—4th qtr. 1952	1,924	978
Service Pipe Line Company..... 41 mi. 4 in., 6 in., and 8 in. in Williams and Mountrail counties, North Dakota. Estimated cost—$380,000 Estimated completion date—4th qtr. 1952	1,559	724
Toronto Pipe Line Company Sterling System 53 mi. 12 in. from producing areas in Sterling and Logan counties, Colorado, to Gurley, Nebraska. Initial capacity—24,000 bbl per day Estimated cost—$2,200,000 Estimated completion date—4th qtr. 1952	9,174	491
Buckeye Pipe Line Company..... 15.6 mi. 12 in. loop between Cygnet, Ohio, and Samaria, Michigan. Capacity increase—15,000 bbl per day Estimated cost—$545,000 Estimated completion date—1st qtr. 1953	1,599	1,515
Malco Refineries, Incorporated..... 62 mi. of 4 in. from Tocita Field, New Mexico, to Hospah field, New Mexico. Initial capacity—3,500 bbl per day Estimated cost—$400,000 Estimated completion date—4th qtr. 1952	1,770	1,470
Sun Pipe Line Company..... Lay 27 mi. 4 in., 6 in., and 8 in. to connect new production in Southwestern Fisher County, Texas. Estimated cost—$445,000 Estimated completion date—4th qtr. 1953	1,627	622
Interstate Pipe Line Company..... 138 mi. 22 in. and 14 mi. 18 in. to revise present system between Louisiana-Texas border near Shreveport to Baton Rouge, Louisiana. Capacity increase—26,000 bbl per day Estimated cost—$10,020,000 Estimated completion date—3rd qtr. 1953	30,292	9,908
Humble Pipe Line Company..... 30 mi. 16 in. and 41 mi. 18 in. from Hawkins field, Texas, to Texas-Louisiana state line. Initial capacity—77,000 bbl per day Estimated cost—$2,758,000 Estimated completion date—3rd qtr. 1953	9,500	3,740
Buckeye Pipe Line Company..... 74 mi. 16 in., 186 mi. 14 in., 96 mi. 10 in., and 8 mi. 8 in. from Linden, New Jersey, to Rochester and Syracuse, New York, via Allentown, Pennsylvania, and other intermediate points. Initial capacity—80,000 bbl per day Estimated cost—$24,000,000 Estimated completion: to Allentown—4th qtr. 1952; to Buffalo—3rd qtr. 1953	46,163	1,041
Phillips Petroleum Company..... 54 miles 8 in. loops between Goldsmith and Borger, Texas, and 50 miles 8 in. from Spraberry gasoline plant to Goldsmith. Capacity increase—8000 bbl per day Estimated cost—$3,000,000 Estimated completion date—1st qtr. 1953	6,780	3,383
United States Pipe Line Company..... 550 mi. 24 in. from Port Neches, Texas, to Jackson, Tennessee, and 1045 mi. 22 in. from Jackson to Newark, New Jersey. Also 365 mi. of various branch and feeder lines. Initial capacity—300,000 bbl per day Estimated cost—$141,091,000 Estimated completion date—4th qtr. 1953	319,50[illegible]	20,000
Standard Oil Company (Indiana)..... 316 mi. of 12 in. from Sugar Creek, Missouri, to Dubuque, Iowa. Initial capacity—40,000 bbl per day Estimated cost—10,430,000 Estimated completion date—4th qtr. 1952	33,1[illegible]	2,000
The Texas Pipe Line Company (Evangeline System)..... 196 mi. 16 in. from Port Arthur, Texas, to Baton Rouge, Louisiana. Initial capacity—96,000 bbl per day Estimated cost—$12,900,000 Estimated completion date—2nd qtr. 1953	28,451	28,451
Phillips Petroleum Company..... 14 mi. 8 in. and 22 mi. 6 in. from Plymouth-Benedum Plant to Spraberry Plant in West Texas. Initial capacity—5,000 bbl per day Estimated cost—$1,015,000 Estimated completion date—2nd qtr. 1953	1,983	1,983
Salt Lake Pipe Line Company..... 329 mi. of 8 in. loops between Salt Lake City, Utah, and Boise, Idaho. Capacity increase—17,000 bbl per day Estimated cost—$8,000,000 Estimated completion date—4th qtr. 1952	20,290	3,390
Sinclair Pipe Line Company (Harbor Products)..... 90 mi. of 16 in. from Philadelphia area to New York Harbor area. Initial capacity—110,000 bbl per day Estimated cost—$8,911,000 Estimated completion date—1st qtr. 1953	14,894	14,894
Bell Oil and Gas Company..... 145 mi. 6 in. and 8 in. from Ardmore, to Drumright, Oklahoma. Initial capacity—9,000 bbl per day Estimated cost—$3,270,000 Estimated completion date—2nd qtr. 1953	9,006	3,550
Indiana Farm Bureau Association, Inc..... 230 mi. 8 in. and 4 in. line from Mount Vernon, to Peru, Indiana. Initial capacity—12,000 bbl per day Estimated cost—$5,208,000 Estimated completion date—2nd qtr. 1953	2,512	1,256

Gas Lines Get 304,381 Tons Steel

Five major natural gas pipe line projects with a total estimated construction cost of $281,024,000 have been given priorities assitance for purchase of line pipe for the fourth quarter of 1952, Deputy Petroleum Administrator J. Ed Warren announces. In addition a large number of smaller gas projects also have been given priorities assistance by the Petroleum Administration for Defense, he said.

There were 136,800 tons of pipe allocated for the fourth quarter to the five major projects.

Three of the projects are getting steel for the first time:

1. Field gathering system and transmission line of Wilcox Trend Gathering System to supplement supplies to Texas Eastern Transmission Corporation for maintenance of their present transmission system.

2. Looping of the existing Texas-to-New England system of Tennessee Gas Transmission Company to provide additional gas for New England, the Appalachian area, and storage.

3. Looping of a section of the existing system of Pacific Gas and Electric Company to provide for additional Texas gas for California.

Two other major projects had been given allotments of pipe earlier:

1. Looping of the existing Texas-California system of the El Paso Natural Gas Company to provide additional gas for California.

2. Looping and extension of the Southern Natural Gas Company system for additional supplies to its entire market area.

An additional 167,567 tons of pipe have been allocated to more than 400 smaller projects, including gathering lines, distribution lines, other facilities, and MRO (maintenance, repair, and operations).

Total pipe allocated to date for the quarter is 304,381 tons.

Details of the five major projects given priorities assistance for the fourth quarter are the following:

Company	Estimated cost	Estimated completion date	Capacity, cu ft day	4th qtr. line pipe require.
Wilcox Trend Gathering System	$ 10,090,110	4Q52	100,000,000	20,952 tons
El Paso Natural Gas	51,720,000	4Q52	200,000,000	20,505
Tennessee Gas Transmission	128,216,000	4Q53	317,000,000	42,854
Pacific Gas and Electric	13,322,000	4Q52	100,000,000	17,000
Southern Natural Gas	77,675,600	2Q53	350,000,000	35,503
Total major projects	$281,023,710		1,067,000,000	136,814
Other projects				167,567
Total line pipe allocations 4th quarter 1952				304,381

Deliveries of the pipe are dependent on the continuing effects of the steel strikes.

Salt Lake Pipe Line Company Awards Contracts

Award of contracts for construction of a 330-mile oil products pipe line from Salt Lake to Boise, Idaho, has been announced by Salt Lake Pipe Line Company, a subsidiary of Standard Oil Company of California.

First portion of the 8-in. line, from Salt Lake City to Juniper, Idaho, will be built by Macco Corporation of Southern California. The remaining 200 miles to Boise will be built by Engineers Limited Pipe Line Company of San Francisco.

Contracts for the $8,000,000 project call for completion of the line by the end of the year.

Two years ago Salt Lake Pipe Line Company built its initial oil products line to Boise, and later extended it to Pasco, Washington. Pipe to be laid this fall will parallel the existing route, and its completion will boost the company's transportation capacity between these points from 22,000 bbl to 39,500 bbl a day. With the addition of supplementary pump stations it would be possible to raise this capacity to 45,000 bbl a day.

The new pipe line will tie into existing take-off points along its route in Utah and Southern Idaho.

Line Pipe Purchasers Not Required to File PAD-73

Although Form PAD-73, which was used in reporting line pipe purchases, has been discontinued, the Petroleum Administration for Defense is still getting many requests from operators for the form, Deputy Petroleum Administrator J. Ed Warren says. Line pipe purchases now are reported through the filing of purchase orders, he pointed out.

Form PAD-73 was sent to all gas operators who had received priorities assistance on large construction projects before May 19, 1952.

Since Form PAD-73 was discontinued, PAD has requested all gas operators authorized to buy more than 50 tons of line pipe on any PAD-26 project or on a PAD-26LP application to file with the agency a copy of each purchase order for line pipe within 48 hours after mill acceptance of the order. This procedure, Warren explained, keeps PAD informed of the flow of line pipe from the mills to the operators and makes unnecessary the use of Form PAD-73.

Each copy of a purchase order sent to PAD must show: (1) The PAD file number of the project on which the pipe is to be used; (2) the quarter in which delivery of the pipe is to be made; (3) the total tonnage on each size of pipe to be delivered.

Crutcher-Rolfs-Cummings Forms Supply Division

Crutcher-Rolfs-Cummings, Inc., has announced the formation of the C-R-C Supply Division with offices at 7825 Katy Road, Houston, Texas. A complete line of pumps, valves, fittings, and hand tools is stocked. I. W. McKinney is manager of the new division.

Trans Mountain to Be Completed Ahead of Schedule

The Trans Mountain Oil Pipe Line between Alberta, Canada, and the Pacific Coast will be completed in August, 1953, and crude oil should reach Vancouver through the pipe line during October of next year, several months ahead of the originally contemplated completion date.

The initial tariff for transporting oil from Edmonton to Vancouver, based on present estimates of costs and a presently indicated initial throughput of approximately 75,000 bbl a day, will be 45 cents per bbl.

The loading charge at the Vancouver marine terminal of the pipe line company is expected to be 2½ cents per bbl for approximately half of the initial throughput, which will be exported by tankers from Vancouver to California, the Pacific Northwest, or other offshore points.

These statements were made by Robert L. Bridges, president of Trans Mountain Oil Pipe Line Company, following a meeting of the company's board of directors held in Toronto.

In making the announcement, Bridges emphasized that the proposed tariff rate is based on present estimated costs and on the quantities of crude oil currently indicated to be transported through the pipe line on its completion. As the crude oil to be transported materially increases in quantity, the tariff rate per barrel may be lowered still further.

"Construction is proceeding according to schedule," Bridges said. "As of the end of August, 1952, approximately 150 miles of the 711-mile pipe line had been welded. Welding is currently proceeding at the rate of approximately 3 miles per day. By the end of the construction season this fall, between 330 and 400 miles of the pipe line should be welded."

Next summer Trans Mountain plans to have five to seven pipe line spreads along the route, compared with three this past summer and five this fall. The number of spreads during 1953 required to complete the pipe line in order to have it completed in August next year will be determined this winter, and will depend on how late fall weather conditions will permit the spreads now on the line to continue to work economically.

One of the three spreads operating this summer has been working from a point east of Vavenby, British Columbia, eastward toward Blue River, British Columbia. Shortly, this spread will go back to its starting point near Vavenby and proceed westward through Black Pool, British Columbia, toward Kamloops, British Columbia. The other two spreads started from Grantbrook, Alberta, near the summit of the Canadian Rockies—one working eastward through Jasper, Alberta, toward Edson, Alberta, and the other westward through Valemount, British Columbia, toward Blue River. Two additional spreads are getting under way this month—one working westward from Chilliwack, British Columbia, toward Hope, British Columbia, and the other from Acheson, Alberta, to Edmonton, Alberta.

The area to be constructed during 1953 consists of stretches from the vicinity of Acheson to Edson, west of Valemount to Blue River, east of Kamloops through Merritt, Coquihalla to Hope, and from Chilliwack to Burnaby outside of Vancouver.

Sunray Consolidates Pipe Line Systems

The various pipe line systems of Sunray Oil Corporation and its subsidiary pipe line companies have been consolidated into one operating division of the company's manufacturing, sales, and pipe line department, according to announcement by H. W. Manley, vice president in charge. Purpose of this consolidation is to obtain a more uniform and efficient operation of all pipe line systems operated by Sunray.

J. R. (Dick) Ellis has been named division manager of Sunray's new pipe lines and terminals division, and R. E. Sleppy will be assistant manager of this division.

Superintendents of the various Sunray pipe line segments will be as follows: George Martin, superintendent of Sunray Coastal Pipe Line Company, Victoria, Texas; R. T. Plaisance, superintendent of Sunray Pipe Line Company, Bristow, Oklahoma; C. V. Bishop, chief operator, Sunray Oil Corporation's Duncan-Allen utilities pipe line, Wynnewood, Oklahoma, and M. E. Carroll, chief operator, Duncan, Oklahoma; R. E. Gilmore, superintendent, Allen pipe line gathering system, Allen, Oklahoma; George Vaughn, superintendent of Velma pipe line gathering system, Velma, Oklahoma. Joe Kanive is foreman of the Sunray Coastal Pipe Line Company segment at DeQuincy, Louisiana.

Safety Winners Honored

H. C. Price Company, pipe line constructors of Bartlesville, Oklahoma, gave a dinner party at Dyersburg, Tennessee, on September 4 for foremen and key personnel of its Spread Two in recognition of their record-breaking safety achievements during the past year.

The spread was awarded a bronze plaque for having established the lowest accident frequency record among Price construction crews. The spread's new superintendent, R. L. "Bob" Ezell, also was honored for having directed his welding crew through 100,000 man-hours without a disabling accident.

Ezell received a Remington automatic shotgun from the Price company for having compiled the amazing total of 117,434 accident-free man-hours while serving as foreman of the welding gang.

Spread Two established a 20.4 accident frequency per million man-hours worked during last year's construction season. This compared with the company-wide average of 43.7 accidents per million man-hours.

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24,900 Miles Gas Lines Goal for 1953

An expansion goal for the gas utility industry for 1953, expressed in mileage of pipe lines to be constructed in that year, has been announced by the Defense Production Administration, as follows:

Large pipe ..... 7,200 miles
Small pipe ..... 17,700 miles

DPA explained that large pipe is defined as having an outside diameter of 16 in. or over. Such pipe generally is used for transmission lines. For this goal the average outside diameter of pipe is figured at 20 in. and the average weight as 207.5 net tons per mile. The 7200 mileage figure is equivalent to approximately 1,494,000 tons of pipe.

Small pipe, that having outside diameter of under 16 in., generally is used for field, gathering, and distribution purposes. For this goal the average diameter is 6⅝ in. and the average weight 39.5 tons per mile. The 17,700 mileage figure is equivalent to approximately 699,000 tons of pipe.

DPA said no exact statistical basis is available for comparing the 1953 expansion goal with previous years, but said that gas industry statistics reported total miles of utility gas main had increased from 387,500 in 1950 to 406,600 in 1951, an increase of 19,100 miles.

Natural gas mains increased from 314,500 to 342,400 miles. Manufactured gas mains decreased from 55,400 to 36,500 miles. Mixed gas mains increased from 12,000 to 22,100 miles. Liquefied petroleum gas mains remained the same at 5600 miles.

The expansion goal is based on data submitted by the Petroleum Administration for Defense. Total estimated sales of all types of gas by all gas utilities in millions of therms follow:

1952	1953	1954	1955
56,596	62,199	66,179	69,798

These figures represent percentage increases over 1952 as follows: 1953, 10 per cent; 1954, 17 per cent, and 1955, 23 per cent.

Total requirements of natural gas alone of all gas utilities are estimated in billions of cubic feet as follows:

1952	1953	1954	1955
6,060	6,750	7,191	7,563

These figures represent percentage increases over 1952 as follows: 1953, 11 per cent; 1954, 18 per cent; 1955, 25 per cent.

Expansion goals provide the basis by which the government can assist in the achievement of the needed expansion through accelerated tax amortization or other means.

Establishment of a goal does not constitute a commitment to supply controlled materials as of any given quarter. The actual allotment in each quarter will be conditioned by available supply and competing demands.

John Merriam to Board of Canadian Corporation

John Merriam, president of Northern Natural Gas Company, has been elected to the board of directors of the Calgary and Edmonton Corporation, Ltd., of Winnipeg, Canada, large holder of natural gas, oil, and mineral rights in the Province of Alberta. Merriam is the only United States citizen on the board; others are from Canada and England.

The Canadian company has the natural gas, oil, and mineral rights to more than a million acres in Alberta including about half of the acreage in the important Pincher Creek gas field under lease to the Canadian Gulf Oil Company. This Pincher Creek gas may eventually find its way into Northern's pipe line system. Northern has a contract to purchase natural gas from Western Pipe Lines of Canada who is negotiating to purchase Pincher Creek gas from the Canadian Gulf Oil Company. The Pincher Creek gas reserve is estimated at one and a half trillion cubic feet.

Northern now has an application pending before the Federal Power Commission for permission to construct a line from the Canadian border to the Minneapolis and St. Paul area, the northern terminus of Northern's pipe line system. Western Pipe Lines Company is seeking a permit to export natural gas from the Province of Alberta.

For many years the Calgary and Edmonton Corporation leased its rights to other companies, retaining royalties on production, but more recently has supplemented this with activity on its own behalf in the exploration and development of other properties in association with the Anglo-Canadian Oil Company and the Home Oil Company.

Besides the Pincher Creek fields, Calgary and Edmonton has interests in many other gas and oil bearing areas of Alberta, including the important Turner Valley area, where the company has royalty interests in 71 oil wells and 19 gas wells.

R. P. Lennart President Tulsa Pipe Liners Club

R. P. Lennart, supervisor of oil movements, Service Pipe Line Company, Tulsa, Oklahoma, was elected president of the Pipe Liners Club of Tulsa at the September dinner meeting. D. B. Good, chief engineer, The Texas-Empire Pipe Line Company, Tulsa, was chosen vice president; G. P. Jennings, superintendent of operations, products transportation, Phillips Pipe Line Company, Bartlesville, treasurer, and Ben D. Leuty, assistant chief engineer, Cities Service Pipe Line Company, Bartlesville, secretary.

New directors are F. C. Whiteside, Continental Pipe Line Company, Ponca City; V. J. Sittel, Service Pipe Line Company, Tulsa, and George B. Randels, Interstate Oil Pipe Line Company, Tulsa. Holdover directors are A. H. Newberg, Service Pipe Line Company, Tulsa, and J. D. Jones, Gulf Refining Company, Tulsa.

Officers whose terms expired were Whiteside, president; Lennart, vice president; Good, secretary, and Leuty, treasurer.

Texas Gas Bond Sale to Finance New Construction

Texas Gas Transmission Corporation has announced completion of the sale of $37,000,000 of first mortgage 4 per cent pipe line bonds to a group of 14 institutional investors. Sale of $24,000,000 of the bonds has just been made. The first $13,000,000 of the issue was sold last February to the same 14 investors.

W. T. Stevenson, president of Texas Gas, said $33,700,000 of the funds realized from the bonds will be used to finance the company's new 408-mile 26-in. natural gas pipe line now under construction, as well as the installation of additional horsepower at its compressor stations at Jeffersontown and Hardinsburg, Kentucky, and Bastrop, Louisiana, and construction of new compressor stations near Dillsboro, Indiana, and Shreveport, Louisiana.

The remainder of the proceeds will be applied by Texas Gas toward the cost of construction last year of a 26-in. supply line from Bastrop, Louisiana, to Eunice, Louisiana.

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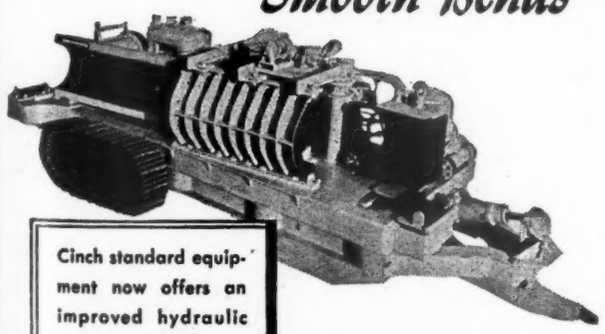

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Edwin L. Hall Awarded Walton Clark Medal

For his contributions to the gas industry in the United States, Edwin Loy Hall of Cleveland, Ohio, will be awarded a Walton Clark Medal by The Franklin Institute of the State of Pennsylvania. Hall is director of the testing laboratories of the American Gas Association.

Formal presentation of the award will be made at the Institute's Medal Day ceremonies in Franklin Hall on October 15.

The citation accompanying the medal states that it was awarded to Hall "in consideration of his many contributions to the gas industry, in the improvement of old processes for gas manufacture, for the development of new processes for the production of valuable by-products by the pyrolysis of petroleum oils, and for the invention of a new and more efficient process for the production of high heating value gas as a substitute for natural gas."

Hall has devoted his entire professional life to the gas industry. Born in 1902 in Canton, Ohio, he was graduated from Ohio State University in 1924 with a degree of BS in metallurgical engineering. After working for the United Gas Improvement Company in Philadelphia and the Syracuse Lighting Company in Syracuse, New York, he subsequently was research engineer for 11 years for the United Gas Improvement Company. For the next 5 years he was in charge of the Manchester, New Hampshire, Gas Company as treasurer, clerk, and manager.

From 1945 to 1947 he was secretary-coordinator of the Gas Production Research Committee of the American Gas Association. From 1947 to date he has been director of their Laboratories in Cleveland, Ohio, and Los Angeles, California, and since 1950 has been assistant managing director of AGA.

Continental Announces Completion of Line

Continental Pipe Line Company, a subsidiary of Continental Oil Company, has announced completion of an 8-in. 105-mile pipe line extending from the Rincon field in Starr County, Texas, to Port Isabel, Texas.

The new line replaces a 5½-in. line that was in operation for many years. It has a capacity of 17,000 bbl a day and is moving crude oil from the Rincon area near Rio Grande City, through McAllen to Port Isabel.

In addition, stabilized casinghead from a cycling plant near McAllen, and crude oil from the McAllen area, are transported to Port Isabel for the Taylor-Mayfair Company.

Rice Institute, Houston, has a one-half interest in the line. E. J. Burkman of McAllen is district superintendent for Continental Pipe Line in the area.

There are about 192 producing oil wells in the Rincon field, which was discovered in 1938. Of this number, Continental Oil Company operates 183 of the wells.

A. J. Gates

Pipe Linings Inc. Appoints Southwestern Representative

Appointment of A. J. Gates as southwestern representative has been announced by Robert C. Sargent, executive vice president of Pipe Linings, Inc., Los Angeles service organization for the concrete lining of pipe lines "in place."

Gates, whose headquarters will be maintained at Ruidoso, New Mexico, brings to Pipe Linings 25 years' experience in water supply and distribution work, both ground and surface. He formerly was assistant city engineer of Wichita Falls, Texas; superintendent and engineer for the Wichita Falls water department; business manager for Midland, Texas, and also was connected with Joe E. Ward, Wichita Falls consulting engineer. He is a member of American Water Works Association and of the American Society of Civil Engineers.

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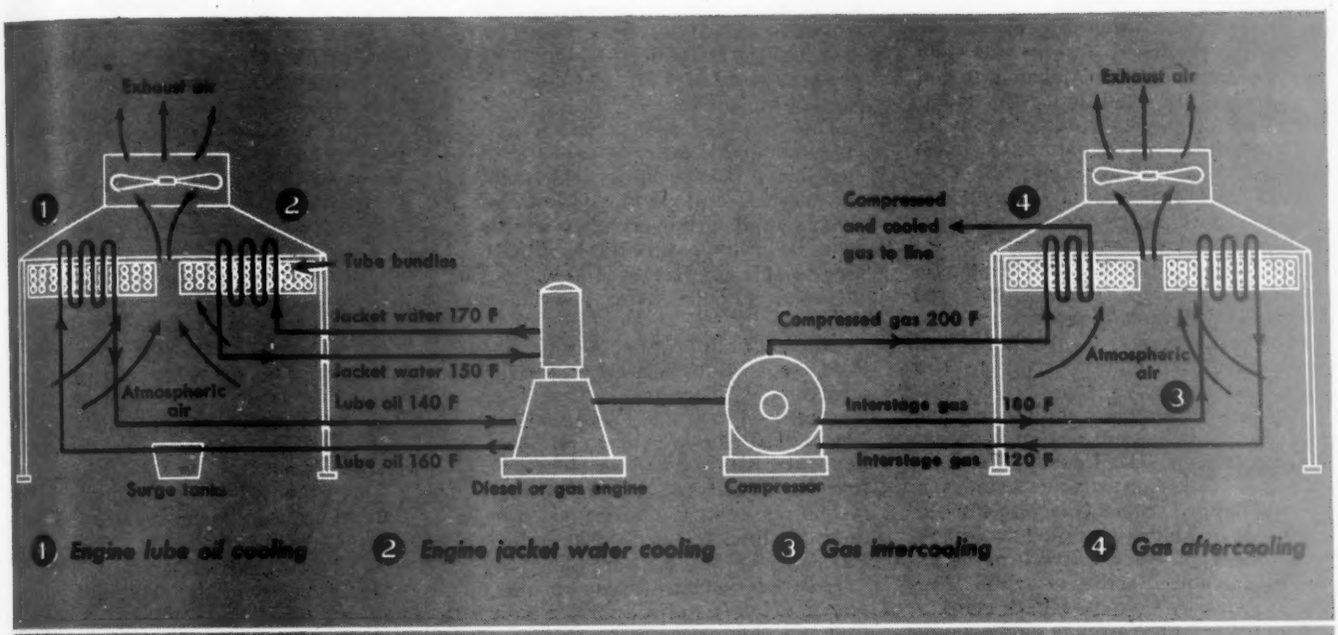

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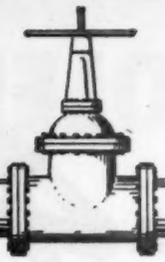
PIPE LINE PROJECTS



Southern Natural to Install New Facilities

The Federal Power Commission has authorized Southern Natural Gas Company, of Birmingham, Alabama, to construct pipe line facilities, estimated to cost $9,265,000, which will increase the delivery capacity of its natural gas transmission system to approximately 670,000,000 cu ft a day, an increase of 115,000,000 cu ft daily over the presently authorized sales capacity.

The new facilities, to be located in Alabama, Georgia, Mississippi, and Louisiana, will include three compressor stations with a total of 19,450 hp and approximately 60 miles of various size pipe lines.

The new compressor stations will be in Jefferson Davis and Clarke counties, Mississippi, and Hale County, Alabama. The pipe line construction includes a 20-mile supply line in Ouachita Parish, Louisiana; 33 miles of triple loop line in Ouachita and West Carroll parishes, Louisiana, and 7 miles of triple loop line in Sharkey County, Mississippi.

The project represents in part a modification of facilities previously authorized by the commission (in Docket No. G-1308), including the construction of about 40 miles of line in lieu of 35 miles of pipe and 6600-hp in additional compressor units. The FPC also approved Southern Natural's plan not to construct about 93 miles of pipe line, a 1600-hp compressor station, and 1200 additional hp at an existing station, as authorized in the earlier proceeding.

Cost of El Paso Projected Work Totals $176,250,000

El Paso Natural Gas Company, of El Paso, Texas, has filed two applications with the Federal Power Commission proposing the construction of pipe line facilities in Texas, New Mexico, and Arizona to increase the daily delivery capacity of its system by a total of 400,000,000 cu ft for use by customers in Texas, New Mexico, Arizona, and California.

The construction proposed in the two applications includes a total of approximately 822 miles of main transmission loop line and is estimated to cost about $176,250,000.

In one of the applications, (Docket No. G-2044), El Paso is seeking authority to build about 725.7 miles of main transmission loop line and a total of 37,400 main line compressor horsepower. The facilities would provide for delivery from the Permian Basin in southeast New Mexico and West Texas of an additional 300,000,000 cu ft of natural gas a day. Two hundred million cubic feet of this gas would be for joint use by Southern California Gas Company, of Los Angeles; Southern Counties Gas Company of California, also of Los Angeles, and Pacific Gas and Electric Company, of San Francisco. The remaining 100,000,000 cu ft would go to present customers in Arizona, New Mexico and Texas.

This proposed project also would include about 181 miles of field transmission lines; 124,100 hp in field compressor stations, and purification, dehydration and amine recovery plant additions. Total estimated cost of the facilities covered by this application is $140,250,000, including $2,500,000 for working capital.

The other application (Docket No. G-2043) requests authorization for the construction of about 96.6 miles of main transmission loop line; 7500 hp in main line and 5500 hp in field compressor stations; dehydration and gasoline absorption plant additions, and field gathering system extensions. Estimated cost of these facilities is $36,000,000, including $500,000, for working capital.

The construction proposed in this application would provide for the delivery from the San Juan Basin of northwest New Mexico and southwest Colorado of an additional 100,000,000 cu ft of natural gas a day for use jointly by the three California customer companies.

FPC Postpones Hearing on Gas Export to Canada

The Federal Power Commission postponed without date the hearing that had been scheduled to begin September 15 in Washington, D. C., on applications by Tennessee Gas Transmission Company, of Houston, Texas, and Niagara Gas Transmission, Ltd., of Toronto, Canada, which are seeking authority to export natural gas from the United States for ultimate consumption in eastern Ontario, Canada.

The commission said that both companies had failed to supply certain data that had been requested. The FPC pointed out that in an earlier case it had stated that in any future proceedings Tennessee would be required to present evidence showing a complete system deliverability study on a year-by-year basis, in applications involving a material increase in its total system deliverability capacity.

The commission said it had requested Tennessee to submit by September 5 such a deliverability study along with other pertinent data, and also had asked Niagara to submit certain pertinent data by September 1. As all of this required data has not been provided, the FPC said, it "is necessary and appropriate for an expeditious hearing" . . . to postpone the September 15 hearing to a date to be fixed by further order.

Texas Eastern Revises Its Pipe Line Proposal

Texas Eastern Transmission Corporation, of Shreveport, Louisiana, has filed an amended application with the Federal Power Commission in connection with its proposal to construct a 315-mile natural gas transmission line extending from a point near Provident City, Lavaca County, Texas, to Castor, in Bienville Parish, Louisiana.

The changes included in the amended application provide for the transportation of 140,000,000 cu ft of natural gas a day through the proposed facilities instead of the 200,000,000 cu ft originally proposed. The estimated cost of the facilities has been changed from $25,943,079 to the presently proposed figure of $23,283,540.

In addition, the 5500-hp compressor station proposed in the original application would not be built, and the wall thickness of the 315 miles of 24-in. pipe would be decreased slightly.

As proposed in the original application, the additional supplies of natural gas still would be used in carrying out previously authorized service. The sourthern terminus of the line, Texas Eastern said, is in one of the major gas producing areas of the Southwest, which is being actively developed for additional production. Texas eastern now purchases gas produced in this area, and said it is making arrangements for additional supplies there and in adjoining areas.

Proposed Facilities Would Serve Storage Field

United Fuel Gas Company, of Charleston, West Virginia, has applied to the Federal Power Commission for authority to construct natural gas pipe line facilities in West Virginia to help expand the company's underground natural gas storage operations.

The project, estimated to cost $6,088,890, would include 50.5 miles of pipe line, and a 2640-hp compressor station. The company also proposes, at an estimated cost of $1,885,800, the acquisition of leaseholds, drilling of wells, and installation of well and field lines in connection with the initiation of operations of a proposed new storage pool.

The proposed compressor station would be in Wood County, West Virginia, at an existing storage pool, and the new pipe line would extend south from the compressor station to the company's existing Lanham station in Putnam County, West Virginia. These facilities would be used to transport and compress gas for injection in and withdrawal from the existing storage pool, and the new proposed storage pool.

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Pipe Line Projects

Underground Storage Project Gets Approval

The Federal Power Commission has approved the first stage of the development of an underground storage area for natural gas in Kankakee and Iroquois counties, Illinois, by Natural Gas Storage Company of Illinois, of Chicago, Illinois.

The project, which is estimated to cost initially $17,000,000, will be used to store natural gas for the account of Natural Gas Pipeline Company of America and Texas Illinois Natural Gas Pipeline Company, both of Chicago. The three companies are subsidiaries of Peoples Gas Light and Coke Company, also of Chicago.

The storage company plans to develop the project over a five-year period, but the application approved by the commission requested only authority for the construction and operation of facilities required in the first year.

The company estimates that 150,000,000 cu ft of gas a day will be delivered from storage during the 1953-54 winter season, and that up to 1,500,000,000 cu ft a day ultimately will be delivered during peak periods.

The initial project includes the drilling of 25 wells and the construction of 16.7 miles of 30-in. pipe line to transport gas to storage during summer and from storage during winter. The project, in its first stage, also will include a 10,000-hp compressor station; a dehydration plant; approximately 8.75 miles of well lines; 25 well meters; one main storage meter, and other auxiliary and appurtenant facilities.

In the later stages of development of the project, the company plans to construct second and third 30-in. pipe lines, about 43 miles in length, and to drill 25 additional wells. The company estimates that over the five-year period of development, a total investment of about $42,000,000 will be needed.

The FPC's order specifies that the authorization covers only the first stage of the development and that no subsequent stage of development shall be undertaken without commission authorization.

Temporary Authority Given For Compressor Stations

The Federal Power Commission has granted temporary authorization to Atlantic Seaboard Corporation, of Charleston, West Virginia, to construct and operate a total of 7640 hp at two new compressor stations in West Virginia, and for United Fuel Gas Company, also of Charleston, to construct storage facilities in West Virginia.

The commission, however, denied a request by Central Kentucky Natural Gas Company, also of Charleston, for a temporary certificate for the construction of about 9 miles of pipe line in Kentucky to increase its capacity to deliver gas to the Cincinnati, Ohio, area. All three companies are Columbia Gas System subsidiaries.

Atlantic Seaboard's two new compressor stations will be built on its 26-in. main transmission line extending from Cobb, West Virginia, to Rockville, Maryland. One station will have a capacity of 5000 hp and the other, 2640 hp. The facilities will be used to transport increased volumes of natural gas to existing customers.

United will build a total of 21.5 miles of pipe line and 4840 hp in compressor capacity. The project will expand the company's underground gas storage operations and protect and replace existing transmission facilities. United plans to acquire and activate 2 additional pools in Wood and Upshur counties, West Virginia, and to construct additional facilities on its system in the general area of Charleston.

New Line Would Serve Northwest Georgia Areas

Construction of a 70-mile system to supply natural gas to four communities in northwest Georgia has been proposed in an application filed with the Federal Power Commission by Chattahoochee Natural Gas Company, of Birmingham, Alabama.

The application says that Southern Natural Gas Company, also of Birmingham, has agreed to supply Chattahoochee with 7,450,000 cu ft of natural gas a day.

Chattahoochee's proposed system would connect with Southern Natural's facilities at a point in Floyd County, Georgia, and would serve Trion, Summerville, LaFayette, and Dalton, Georgia. Estimated cost is $1,533,254.

Pacific Northwest Files Second Amended Proposal

Pacific Northwest Pipeline Corporation, of Houston, Texas, has filed a second substitute application with the Federal Power Commission, proposing to construct a natural gas transmission system extending from the San Juan Basin in New Mexico and Colorado to market areas in the Pacific Northwest.

The proposed system would include approximately 1384 miles of main transmission line, and 316 miles of spur and lateral lines. Estimated overall capital cost of the project is $179,000,000. The system would have a daily capacity of approximately 314,000,000 cu ft of natural gas.

The main line would originate near Ignacio, Colorado, and extend across Utah, Idaho, and Oregon with its terminus near Bellingham, Washington. Laterals and spurs would extend off the main line to Pocatello, Idaho, and to Walla Walla, Spokane, and a point near Hanford and Yakima, Washington. Eight compressor stations, having a total installed horsepower of 61,000, would be situated along the system in Colorado, Utah, Idaho, and Oregon.

The system would serve markets in Washington, northern Oregon, Idaho, and Utah. The company would make natural gas available to utilities that serve various cities in these states, including Salt Lake City and Brigham, Utah; Pocatello, Twin Falls, Boise and Nampa, Idaho; Pendleton, The Dalles and Portland, Oregon; and Walla Walla, Spokane, Hanford, Yakima, Kelso, Olympia, Tacoma, Seattle, Everett, and Bellingham, Washington.

In its original application, filed in June of 1950, Pacific Northwest proposed to build a 2175-mile pipe line system that would have linked the Texas gas reserve areas with gas fields in Alberta to serve the Pacific Northwest. This proposal was revised by the company last March, when it filed its first amended application proposing the construction of about 757 miles of pipe line, mainly in Washington, to serve markets in the Pacific Northwest with natural gas imported from Canada, while at the same time exporting an equal amount of United States gas back across the border near River Rouge, Michigan, for consumption in Canada.

Cities Service to Add Compressor Horsepower

The Federal Power Commission has received an application from Cities Service Gas Company, of Oklahoma City, Oklahoma, requesting authorization for the installation of a total of 11,400 hp at one existing and one new compressor station on the company's natural gas pipe line system in Kansas.

The company proposes to construct three 1600-hp units at is Greensburg compressor station in Kiowa County, and six 1100-hp units at a compressor station in Harvey County. Total estimated cost of the project is $2,781,000. Facilities would be used to help meet demands on Cities Service Transmission.

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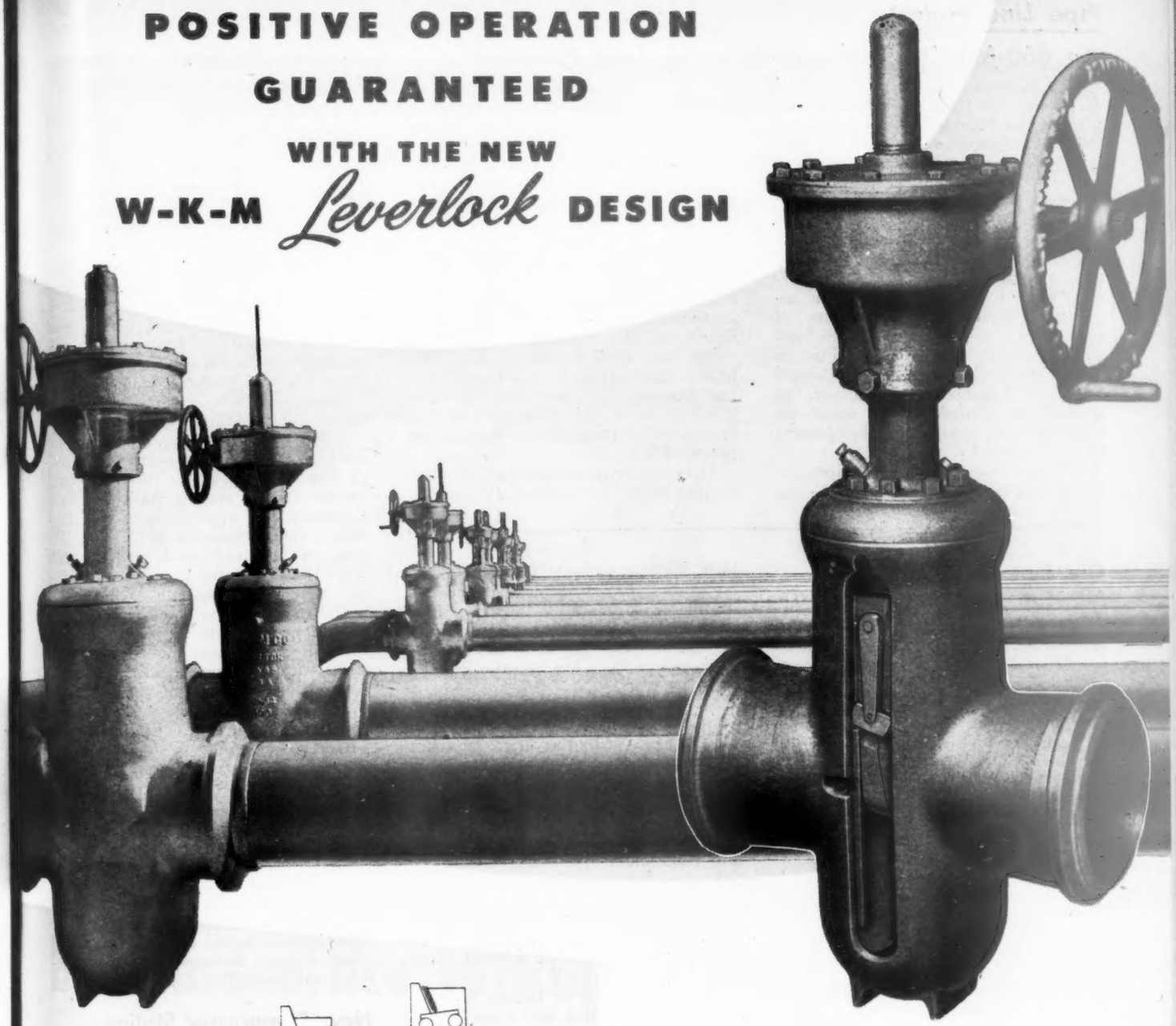

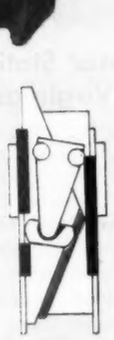

Fig. 1

Fig. 2

Fig. 3

The Leverlock Assembly is a mechanical device which positively holds the gate and segment in neutral position while the valve is being opened or closed, and permits expansion of the gate assembly at the proper time for seating in opened or closed position. A pin in the gate and one in the gate segment are linked together by means of the Leverlock arm. Guides or rails, integral with the seat skirts, provide for the proper movement of the Leverlock arm and shoe as well as guide the vertical travel of the gate assembly. Fig. 1 shows the gate and gate segment in closed position. When the valve is opened, the Leverlock arm swings to the right and travels between the guides on the seat skirt (shown in heavy black). As the Leverlock arm cannot swing to the right or left, it holds the gate and segment in neutral position positively, see Fig. 2. As the gate and segment reach the open position, the Leverlock arm swings into a slot provided on the seat skirt, see Fig. 3, thus permitting the gate and segment to expand against the seats. Clearances are shown in red on drawings above.

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An 860-Mile Louisiana-to-Kentucky Line Proposed

Gulf Interstate Gas Company, a new corporation, of Houston, Texas, has applied to the Federal Power Commission for authorization to construct an 860-mile pipe line extending from southern Louisiana to a point in northeastern Kentucky to transport natural gas for a subsidiary of Columbia Gas System.

The proposed pipe line system, which has a total estimated cost of about $127,887,000, would be used to transport 375,000,000 cu ft of gas a day for the account of United Fuel Gas Company, of Charleston, West Virginia. The gas would be delivered to United Fuel in Boyd County, Kentucky, and to Central Kentucky Natural Gas Company, an affiliate of United's with offices in Charleston, at a point in Montgomery County, Kentucky.

The main 860-mile, 30-in. pipe line would originate at a point in Acadia Parish, Louisiana, and extend across Mississippi and Tennessee, terminating in Boyd County, Kentucky. The project also would include 229 miles of various size lateral lines and five compressor stations, each with a capacity of 8000 hp. The application says that the line is designed for a capacity increase to 565,000,000 cu ft of gas daily, by the addition of compressor facilities.

Gulf Interstate said that United has acquired substantial quantities of gas in Cameron Parish, Louisiana, and is now completing negotiations for gas in Vermilion Parish, Louisiana. According to the application, United would have under contract gas reserves in excess of 2 trillion cu ft, to be dedicated to Gulf Interstate for transmission through the proposed line.

The company proposes to begin transporting gas by November 1, 1954.

Gas Pipe Line for Missouri Sought

Missouri Public Service Company, of Warrensburg, Missouri, has applied to the Federal Power Commission for authority to construct a 136-mile pipe line system in Missouri, and also has asked the commission to order Panhandle Eastern Pipe Line Company, of Kansas City, to supply it with natural gas.

The proposed project, estimated to cost $5,080,845, would include 109.3 miles of main 8 and 10-in. pipe and 27.1 miles of lateral lines. The system would connect with Panhandle's system near New Franklin, Missouri, and extend northwest through Howard, Chariton, Linn, Livingston, and Grundy counties.

The system would carry natural gas for the first time to Glasgow, Salisbury, Keytesville, Dalton, Brunswick, Marceline, Bucklin, Brookfield, Laclede, Meadville, Wheeling, Chillicothe, Chula, Utica, and Trenton. The company presently supplies propane-air gas service to Chillicothe and Trenton.

Missouri Public Service estimates the maximum and minimum day demands, excluding industrial loads, to be carried by the system will be 20,176,000 cu ft and 6,816,000 cu ft, respectively.

Lone Star Constructing 70-Mile Gas Line

The Lone Star Gas Company has begun construction of a 70-mile major transmission line of 20-in. diam from Garvin County, Oklahoma, to Petrolia in Clay County, Texas, where it will feed Lone Star's interconnected pipe line system, according to an announcement by Julian L. Foster of Dallas, general superintendent of the transmission division. The 70-mile main line, plus dehydration stations and field gathering lines will cost in excess of $4,500,000, Foster said.

Having an initial daily delivery capacity of 85,000,000 cu ft of gas, the line will strengthen the gas supply for Lone Star customers in Wichita Falls, Iowa Park, Electra, Vernon, Newcastle, Kirkland, Jean, Dodson, Acme, Burkburnett, Chillicothe, Quanah, Childress, Memphis, Wellington, and intervening points, as well as towns served by Lone Star's 16-in. transmission line between Petrolia and Fort Worth.

The new line will also increase the availability of gas for the Dallas and Fort Worth distribution areas by about 30,000,000 cu ft a day under maximum delivery conditions.

The Garvin County-Petrolia line will take gas from numerous wells in the vast Golden Trend area in Oklahoma and from the Doyle and Velma-Cruce fields in Stephens County, Oklahoma. These and other supplies will require more than 50 miles of gathering lines ranging from 2 to 20-in. in diam. Dehydration plants are to be built at three locations.

After taking off in Garvin County, the transmission line will cross Stephens, Jefferson, and Cotton counties in Oklahoma, span the Red River over Lone Star's pipe line bridge just north of Byers, Texas, and terminate at the company's compressor station at Petrolia, Texas.

Luther Tolbert of Dallas, superintendent of Lone Star's pipe line department, is directing the construction project. Two crews of about 100 men each will work on the main line.

Temporary Authority for Columbia Subsidiaries

Three subsidiaries of the Columbia Gas System, Inc., have received temporary authorization from the Federal Power Commission for the construction and operation of a total of about 63 miles of natural gas pipe lines on their transmission systems in Ohio, Pennsylvania, and New York.

The companies are the Manufacturers Light and Heat Company, Natural Gas Company of West Virginia, and Home Gas Company, all of Pittsburgh. Manufacturers and Natural also were authorized to retire certain facilities.

Northern Natural's 2-Year Program Before Commission

Northern Natural Gas Company, of Omaha, Nebraska, has filed an application with the Federal Power Commission requesting authority to construct pipe line facilities designed to increase its system sales capacity by 300,000,000 cu ft a day, to a total of 1,112,000,000 cu ft of natural gas.

Total estimated cost of the construction program, which would be carried out over a two-year period, is $69,826,000. The project would include a total of about 442 miles of main pipe line additions; installation of a total of 73,600 hp in new and existing compressor stations, and numerous branch lines and branch line additions.

The additional system capacity would be used to transport 300,000,000 cu ft of gas a day, which Northern would receive from Permian Basin Pipeline Company, the application states. Permian a new corporation, of Chicago, Illinois, has an application pending with the FPC to construct a 384-mile pipe line system in Texas and New Mexico, to transport gas from the Permian Basin for sale to Northern.

Northern proposes to complete construction of facilities required to transport 200,000,000 cu ft of the gas which it would receive from Permian by January 1, 1954, and the facilities to transport the remaining 100,000,000 cu ft would be completed a year later.

The first year's construction program, to cost $45,570,000, would include 226.5 miles of main pipe line additions and 42,800 hp in compressor capacity. The second year, Northern would build, at an estimated cost of $24,256,000, about 215.1 miles of main line additions and 30,800 hp in compressor capacity. The new facilities would be in Texas, Oklahoma, Kansas, Nebraska, Iowa, Minnesota, and South Dakota.

New Compressor Stations Proposed for Virginias

Atlantic Seaboard Corporation and Virginia Gas Transmission Corporation, both subsidiaries of the Columbia Gas System, Inc., with offices in Charleston, West Virginia, have asked the Federal Power Commission to authorize the construction of additional compressor station facilities on their main 26-in. natural gas transmission line, which extends from Clendenin, West Virginia, to Rockville, Maryland.

The proposed new facilities would supply approximately 86,200,000 cu ft of additional gas on a peak day to meet requirements. Estimated cost is $6,885,600.

The companies propose to construct a new 5000-hp compressor station in Braxton County, West Virginia; a 6600-hp station in Upshur County, West Virginia, and a 5000-hp station in Shenandoah County, Virginia. In addition, the project would include the supercharging of three units now installed from 880 hp to 1100 hp and installation of one additional 1100 hp unit at an existing compressor station in Hardy County, West Virginia.

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Pipe Line Projects

Columbia Subsidiaries Plan New Construction

Four subsidiaries of The Columbia Gas System, Inc., have applied to the Federal Power Commission for authority to construct a total of about 279 miles of natural gas pipe lines, and to retire about 178 miles of line together with certain compressor facilities, in Pennsylvania, West Virginia, Maryland, and Ohio.

In a separate application, two of the subsidiaries asked the FPC to authorize a merger of their pipe line facilities.

The four companies are The Manufacturers Light and Heat Company, Natural Gas Company of West Virginia, Cumberland and Allegheny Gas Company, and Home Gas Company, all of Pittsburgh, Pennsylvania. In the other application, Manufacturers is proposing to acquire the facilities of Cumberland and Allegheny.

The proposed construction and retirement program involves a total estimated net construction cost of $11,140,447, allowing a credit of $652,900 for the abandoned facilities, which would be salvaged.

Compressor Station Will Serve Peak Requirements

Mountain Fuel Supply Company, of Salt Lake City, Utah, has received temporary authorization from the Federal Power Commission for the construction and operation of a 2640-hp compressor station on its natural gas transmission system in Uinta County, Wyoming.

The proposed project, which is estimated to cost $772,000, is designed to increase the company's deliverability to Utah from 165,000,000 cu ft of gas a day to 177,000,000 cu ft daily. The company said that the facilities will make up the deficit in supply required to serve the peak load heating requirements of firm customers in an area that includes five communities in Uinta County and 33 in Summit, Morgan, Weber, Davis, Salt Lake, Utah, and Tooele counties, all in Utah.

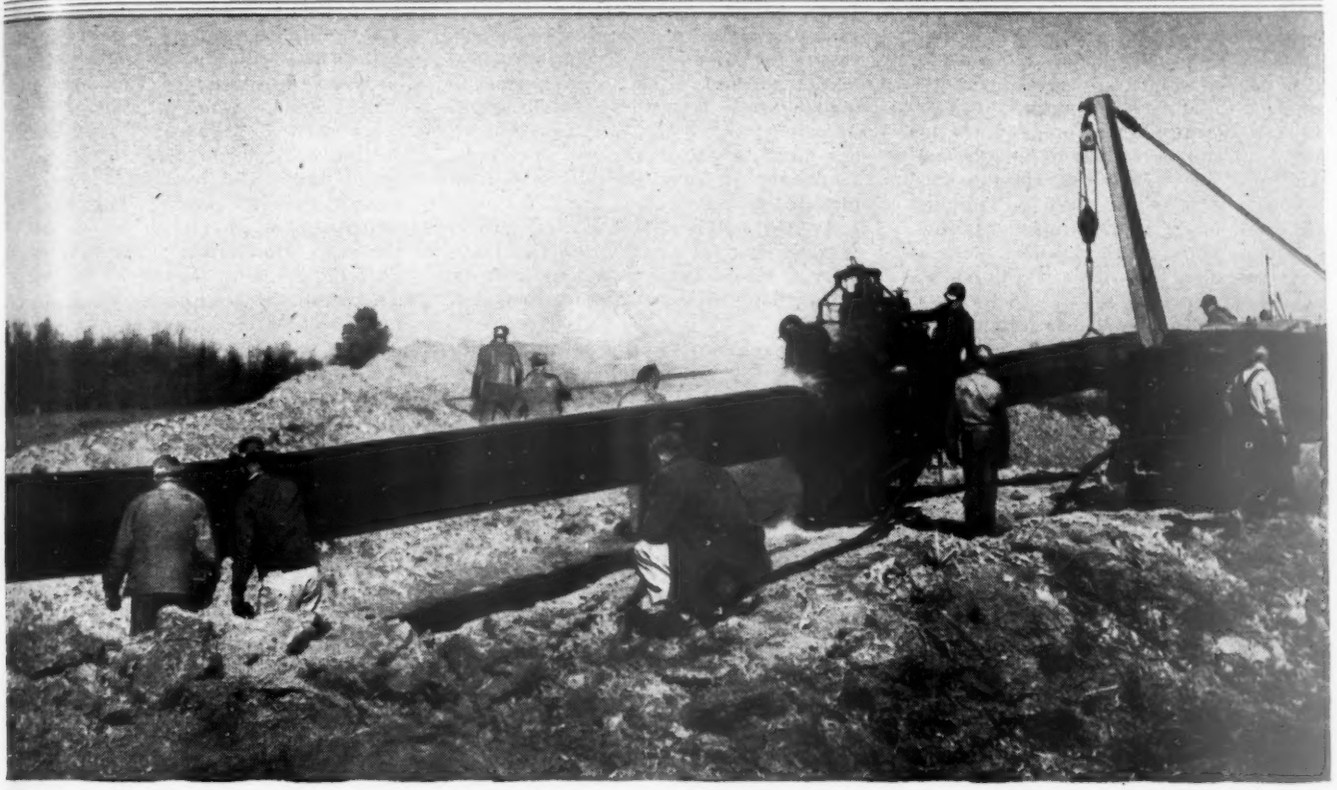
Increase in Gas System Given Temporary Approval

The Federal Power Commission, acting on nine individual applications by Mississippi River Fuel Corporation, of St. Louis, Missouri, has issued a series of certificates authorizing that company to increase the rated daily sales capacity of its interstate natural gas pipe line system from 266,000,000 cu ft to 450,000,000 cu ft of natural gas.

The certificates cover the acquisition, abandonment, relocation, construction, and operation of facilities, most of which are already in operation pursuant to temporary authorization dating back to 1950.

Total cost of the facilities included in the various projects is $17,757,950, based on actual costs of the construction that has been completed and on estimates in the other cases. The facilities are on Mississippi's system in Louisiana, Arkansas, Missouri, Texas, and Illinois.

PIPE LINE PROGRESS



26-inch for Texas Gas Transmission Line

It was in 1950 that Texas Gas Transmission Corporation completed construction of a new, large-diameter natural gas transmission system. It transports gas from Louisiana and Texas reserves to customers in Arkansas, Mississippi, Tennessee, Kentucky, Indiana, Illinois and Ohio.

Additional pipe was lowered in during 1951 to provide increased capacity through looping and extension, lines that will be completed in 1952. These will increase natural gas deliveries to Texas Gas Transmission customers in all these states.

A. O. Smith's contribution to this great addition to the major gas transmission systems of the nation has been shipment of more than 1,300 miles of 26-inch, 20-inch and 16-inch diameter pipe. They were delivered to meet construction requirements for the main line, looping, extensions and some river crossings.

Our welded steel line pipe, internally expanded and accurately sized, constitute a large part of the petroleum and gas transmission lines on this continent. Through the years, A. O. Smith capacity has met the challenge of rapidly expanding pipeline systems that now crisscross America.

A. O. Smith Line Pipe is available in a complete range of sizes and wall thicknesses, from 8⅝-in. to 36-in. diameters.

FIRSTS by A. O. Smith: Welded line pipe • Internally expanded pipe • Light-wall large-diameter pipe • World's largest producer of large-diameter welded steel pipe.

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Seattle 1 • Tulsa 3 • Washington 6, D.C.

International Division: Milwaukee 1

DEPENDABILITY THROUGH RESEARCH AND ENGINEERING

To obtain more information on products advertised see page E-61

With the PIPE LINE CONTRACTORS

Bechtel Corporation, 220 Bush Street, San Francisco 4, California, has four spreads in the field laying 225 miles of pipe line in Connecticut, Massachusetts, and New Hampshire for the Northeastern Gas Transmission Company. Of this total, 100 miles will be 16-in. pipe and 125 miles 3, 4, 6, and 8-in. The job office is at 7 West Main Street, Plainville, Connecticut. S. D. Bechtel, Jr., is division manager; R. L. Bowman, general superintendent, and W. H. Molander, senior office manager.

The spread offices are as follows:

Spread 1: 7 West Main Street, Plainville, Connecticut; V. L. Williams, superintendent.

Spread 2: 52 Pulaski Street, Stamford, Connecticut; J. L. Work, superintendent.

Spread A: P. O. Box 181, Derry, New Hampshire; D. B. Alexander. superintendent.

Spread B: Winsted, Connecticut; M. A. Roberts, superintendent.

Parkhill Truck Company (Stringing Contractor), P. O. Box 1856, Tulsa, has the following jobs underway.

280 miles 14-in. line and 320 miles of 8-in. take-up for Shell Oil Company, from Wood River, Illinois, to East Chicago, Indiana.

100 miles of 16-in. and 125 miles of 3 to 8-in. scattered sections in Connecticut, Massachusetts, and New Hampshire for Northeastern Gas Company. Contractor: Bechtel Corporation. R. C. Parker superintendent.

Houston Contracting Company, 2707 Ferndale Place, Houston, Texas, has the following construction work under contract:

Approximately 190 miles of 24-in. crude oil line for Rancho Pipe Line Company from a point west of Austin, Texas, to Shell Oil Company's Deer Park Refinery near Pasadena, Texas. Oklahoma Pipe Line Constructors (joint venture) has completed approximately 47 miles of their 64-mile section from Deer Park west to the Brazos River. Houston Contracting Company is working on the Brazos and Colorado River crossings. Pipe delivery for section from Brazos River west to vicinity of Austin, Texas, expected in early November. E. C. Norris, superintendent; R. E. Thornton, assistant superintendent; R. J. Axsom, field office manager. Headquarters are at Columbus, Texas.

Approximately 46 miles of 26-in. natural gas line for Texas Gas Transmission Corporation from Beekman compressor station near Bastrop, Louisiana, north to the Mississippi River. E. C. Norris, superintendent; R. E. Thornton, assistant superintendent; R. J. Axsom, field office manager. Headquarters are at Bastrop, Louisiana, and Eudora, Arkansas. Approximately 12 miles completed. (September 22).

Approximately 51 miles of 16-in. crude oil line for Interstate Oil Pipe Line Company, from Sunset, Louisiana, east to the Mississippi River at Anchorage, Louisiana. H. L. Leake, superintendent; S. B. Harrison, assistant superintendent; H. C. MacWhinnie, field office manager; headquarters, Opelousas, Louisiana. Approximately 10 miles completed.

Approximately 88 miles 24-in. natural gas line for Southern Natural Gas Company in Mississippi and Alabama. Work will be handled by two spreads as follows:

Approximately 46 miles in the vicinity of Louisville, Mississippi. F. A. Silar, superintendent; L. F. Redfearn, field office manager; headquarters, Louisville, Mississippi. Scheduled to begin laying pipe September 27.

Approximately 42 miles from Reform, Alabama, to the Warrior River. W. H. Hayes, superintendent; M. L. Thompson, assistant superintendent; J. C. Strickler, field office manager; headquarters, Northport, Alabama. Scheduled to begin laying pipe October 1.

This 88 miles of 24-in. pipe is being double jointed at the Republic Steel Company pipe mill at Gadsden, Alabama. H. J. Muckley is in charge with R. R. Rice welding foreman. Welding began September 21.

Macco Corporation, 14409 South Paramount Boulevard, Paramount, California, has been awarded a contract by Salt Lake Pipe Line Company to lay 113 miles of 8-in. products pipe line between Salt Lake City and Snowville, Utah. This is part of a 333-mile line from Salt Lake City to Boise, Idaho, paralleling an existing system. Al Anthony is in charge of the spread working from Salt Lake City, and Kenny Sills is supervising the spread at Snowville.

Anderson International Contractors, Ltd., 10330—104th Street, Edmonton, Alberta, Canada, has begun work on the 67 miles of 12-in. being laid for Canadian Gulf Pipe Line Company. The operating office and warehouse are at Edmonton. Dick Jernigan is superintendent and Bill Aldrich office manager.

Anderson Brothers Corporation, 6300 Navigation Boulevard, Houston, Texas, has passed the halfway mark on the West Texas Gulf Pipe Line Company job, 80 miles of 24-in. from Colorado City to Midland, Texas. The field office is at Big Spring. Bob McGee is superintendent, Dick Bond office manager, and Tom Marks master mechanic.

Work is expected momentarily to get underway again on the Rancho Pipe Line Company system, which has been shut down because of pipe. This contractor is laying 267 miles of 24-in. from McCamey, Texas, to Cedar Valley. The field office is at Menard. Aldress Kilgore is superintendent, Hamp Hill assistant, and Karl Smith office manager.

Engineers Limited Pipe Line Company, 225 Bush Street, San Francisco, California, will lay 220 miles of 8-in. products pipe line for Salt Lake Pipe Line Company, part of a 333-mile line from Salt Lake City to Boise, Idaho. The section will be from Snowville, Utah, to Boise, Idaho. The line parallels the company's present system. The work is scheduled for completion by the end of the year. The central office is at Twin Falls, Idaho, with Bill Webb in charge. There are three spreads. No. 1 spread has its field headquarters at Glenns Ferry, Idaho, with Louis Robinson superintendent. No. 2 spread is working out of Snowville, with "Ham" Hamilton superintendent, and No. 3 spread has its headquarters at Twin Falls with Bill Cook superintendent. A river crossing crew in charge of R. B. Wilson is working from Glenns Ferry.

From Ventura to Santicoy, California, 12 miles of 22-in. pipe is being laid for Southern California Gas Company. A. E. Heath is superintendent. The field office is at Ventura.

H. C. Price Co.—Pipeline Division, P. O. Box 1111, Bartlesville, Oklahoma, has the general contract covering construction of approximately 363 miles of 26-in. high pressure natural gas loop lines for Texas Gas Transmission Corporation from east bank of Mississippi near Greenville, Mississippi, to Jeffersontown station, Kentucky, a few miles east of Louisville. Spreads as follows:

Cleveland, Mississippi — Box 112 — Telephone 833. (This spread assigned to loops totaling 135 miles): C. R. Ice, superintendent; G. A. Harvey, office manager; C. E. Birmingham, equipment foreman; Jesse Cash and W. O. Elliott, right-of-way foremen; E. W. Whisenant, ditch; Forest Loinette, bending; W. T. Dickerson, pipe; L. O. Reutzel, welding; N. D. Adams, coating; J. C. Rich, lower-in, and J. E. Hamilton, clean-up.

Memphis, Tennessee — General Delivery (This spread assigned to loops totaling 59 miles—pipe gang started September 22): C. E. Shivel, superintendent; D. H. Johnston, office manager; Boyd Danner, equipment foreman; E. D. Worley, road crossings; C. F. Jones and R. H. Edwards, right-of-way foremen; Ray Drewell, ditch; Virgil Huff, bending; R. E. Carriker, pipe; John Stokes, welding; Henry Hill, coating; Bill Buchanan, lower-in, and Paul McCormick, clean-up.

Dyersburg, Tennessee — General Delivery—Telephone 280 (This spread assigned to loops totaling 80 miles—pipe gang started September 8): R. L. Ezell, superintendent; W. R. Crego, office manager; Tommy Stammer, equipment foreman; Cleo Robertson, road crossings; J. D .White, right-of-way; W. H. Olrich, ditch; J. H. Latham, bending; Delbert Shivel, pipe; J. H. Riley, welding; J. B. Northcutt, coating; C. W. Sisco, lower-in; S. L. Price, clean-up.

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Pipe Line Contractors

Fulghum Contracting Corporation, P. O. Box 1181, Harrisburg, Pennsylvania, has under construction 100 miles of 4, 6, 8, and 10-in. pipe line for Algonquin Gas Transmission Corporation, sub-contracted from Associated Pipe Line Contractors, Inc. The work is in Massachusetts and Rhode Island. The field office is at 225 Chase Street, Somerset, Massachusetts. R. L. McMillon is superintendent and Walter Kankowsky office manager.

H. B. Zachry Company, P. O. Box 2570, San Antonio, Texas, has contracted 315 miles of 24-in. for Texas Eastern Transmission Corporation, from Provident City, Texas, to Castor, Louisiana. The central office will be at Huntsville, Texas, telephone 1683, with D .D. Shrum the general superintendent. One spread office will be at Columbus, Texas, with Billy Cole superintendent, the other at Logansport, Louisiana, W. F. Huff superintendent.

Britton Contracting Company, Inc., 93 South Main Street, Washington, Pennsylvania, has been working about a month on 108 miles of 8-in. pipe line for Sun Pipe Line Company between Fostoria and Hudson, Ohio. The field office is at Tiffin, Ohio, telephone 717. Fred McKenzie is superintendent, George Fleming office manager, and John Riggert chief inspector.

Associated Pipe Line Contractors, Inc., 3272 Westheimer Road, Houston, Texas, expects to complete sometime in November the 200 miles of 3-in. through 16-in. pipe line under construction for the Algonquin Gas Transmission Company in Massachusetts, Rhode Island, and Connecticut. One field office is at Taunton, Massachusetts, where L. H. Gray is superintendent, Jack Bradley office manager, and L. F. Shontel master mechanic. A second spread is at Norwich, Connecticut, with Cecil Rogers superintendent and Ralph Herwig office manager.

Conyes Construction Company, 2884 San Pablo Avenue, San Pablo, California, is nearing completion of its work for Ohio Oil Company, which consists of 320 miles of 10 and 12-in. and 25 miles of 8-in. as well as a river crossing, in Ohio and Illinois. The project office is at Mansfield, Ohio, with Al Poggi superintendent and Fred King office manager. There are two spreads in the field. One has its field office at Marion, Ohio, with M. A. Norwood superintendent, Dick Comstock office manager, and J. W. Trim master mechanic. The second spread has its office at Wooster, Ohio, with J. L. Walker superintendent and E. E. Haworth office manager.

Brown Lite Company, 135 North Sheridan Road, Tulsa, Oklahoma, is laying 43 miles of 10-in. pipe line for Arkansas-Missouri Power Company between Campbell, Missouri, and Blytheville, Arkansas, 12 miles of which had been completed to September 16. H. E. Lipke is office manager; Charles D. Taylor, foreman of right-of-way and road crossings; Bluford M. Miller, ditch foreman; Ralph Williams, pipe; Tom Taylor, coating; Eddie Doyle, welders; Richard B. Alexander, lowering-in; Lawrence Triggs, mechanic, and A. B. Jordan (timechecker).

For Sohio Pipeline Company, 185 miles of 6-in. pipe is being taken up between Stoy, Illinois, and Hagerstown, Indiana. A. C. Holder is superintendent; Carl Huffaker, office manager; Clois Huffaker, timechecker; M. A. Thompson, purchasing; Grant W. Friend, take-up foreman; A. M. Murphy, fence; Harry L. Peal, clean-up; Larry Skoog, yard foreman, and Ray E. Curtis mechanic.

Sparling-Davis Company, Ltd., 7310 99th Street, Edmonton, Alberta, Canada, has under construction approximately 185 miles of 10-in. products pipe line for Trans-Northern Pipe Line Company, extending from Kingston to Hamilton. Two spreads are working. One is at Napanee, Ontario, with Ray Abney superintendent, Chet Beighle office manager, and John Gregory master mechanic. The second spread has its field office at Bowmanville, Ontario. E. C. Worley is superintendent and James C. Wagner office manager.

Williams-Austin Company, Grant Building, Pittsburgh, Pennsylvania, will start November 1 on 29 miles of 20-in. pipe line between Tonkin station and Kittanning, Pennsylvania, for New York State Natural Gas Corporation. The work should be completed by December 15. The warehouse and field office will be at Apollo, Pennsylvania; telephone 72-3001. Two spreads will be employed, Ralph Gaddy and Howard Bauer being the superintendents. Ed Peters is general superintendent, and E. E. Mayes timekeeper.

O. R. Burden Construction Corporation, 6702 East 21st Street, Tulsa, Oklahoma, has sub-contracted from Britton Brothers Contracting Company, 12 miles of 22-in. from Sinclair's refinery at East Chicago, Indiana, to Dyer, Indiana; 45 miles of 22-in. from Flanagan, Illinois, northeast, and 40 miles of 22-in. from Forest City, Illinois, northeast. Fred Byers has charge of the East Chicago-Dyer work, headquarters being at the former point. Fred Peters is spreadman and Bill Clyma office manager. Al Perry is in charge of a spread working from Dwight, Illinois. Kelley Strickland is office manager. This work is all on Sinclair Pipe Line Company's new Drumright-East Chicago system. Floyd Lewis is in charge of another spread that has been at work on this project for some time, 90 miles between Quincy and Forest City, Illinois. The field office is now at Astoria. Howard Smith is office manager.

The contractor also is taking up 425 miles of 8 and 12-in. pipe for Sinclair between Salisbury, Missouri, and Wood River, Illinois. The crew working from Moberly, Missouri, has Paul Thibodaux as its superintendent and Guy Carder office manager. The second crew is at St. Peters, Missouri. Whitey Gould is superintendent and E. A. Bell office manager.

Sheehan Pipe Line Construction Company, 529 National Bank of Tulsa Building, Tulsa, Oklahoma, began work late in September on 36 miles of 12-in. products pipe line for Standard Oil Company of Indiana. The pipe is being laid between Kansas City, Missouri, and Polo, Missouri. J. W. Brown is in charge. C. M. Brown is superintendent of the spread laying 12 miles of 6-in. for Wisconsin Natural Gas Company from Fort Atkinson to Jefferson, Wisconsin.

Western Pipe Coating Company, Inc., P. O. Box 181, Iola, Kansas, has subcontracted from Engineers Limited Pipe Line Company the coating of 140 miles of 8-in. pipe on the Salt Lake Pipe Line Company system, a products line. The section is from the southern Idaho border to Boise. The north spread has Cecil D. Carey as superintendent and Chester C. Hall spread foreman. C. M. "Peewee" Vaughn is superintendent of the south spread and H. W. Carey foreman. Ralph Sinclair is office manager for both spreads.

Midwestern Constructors, Inc., 105 N. Boulder, Tulsa 3, Oklahoma, makes this construction report as of September 15:

Aluminum Ore Company, Bauxite, Arkansas. Process piping, fabrication 80 per cent completed; installation 60 per cent completed. Earl S. Powell, superintendent; Morris Garey, office manager; Jack Graham, Elwood Rolfs, and Ralph Bray are the area superintendents.

Natural Gas Pipe Line Company of America, Chicago, Illinois. Manifold alterations at station 107, Emerson, Iowa; 80 per cent completed. Walter D. Smith, Jr., superintendent; Dale Baird, engineer, and O. L. Westrum, office manager.

Manifold alterations at station 108, Truro, Iowa; 80 per cent completed. Orrin J. Watrous, superintendent; Pat T. Moore, engineer, and R. E. Brewer, office manager.

Sinclair Pipe Line Company, Independence, Kansas. Construct pump station, Quincy, Illinois; 40 per cent completed. Ray M. Johnson, superintendent; Charles Malone, engineer, and W. D. Kaufman, office manager.

Install piping at Humboldt, Kansas, station; 30 per cent completed. W. E. Taylor, superintendent, and J. A. Stokes, office manager.

Construct pump station, Pontiac, Illinois; 20 per cent completed. K. L. Kreamalmyer, superintendent; Fred Trompler, engineer, and Duane C. Routh, office manager.

Britton Brothers Contracting Company, 812-13 Dan Waggoner Building, Fort Worth, Texas, as prime contractor, has sub-contracted to O. R. Burden Construction Corporation, 12 miles of 22-in. from Sinclair's refinery at East Chicago, Indiana, to Dyer, Indiana; 45 miles of 22-in. from Flanagan, Illinois, northeast, and 40 miles of 22-in. from Forest City, Illinois, northeast. This work is on Sinclair Pipe Line Company's new Drumright-East Chicago system.

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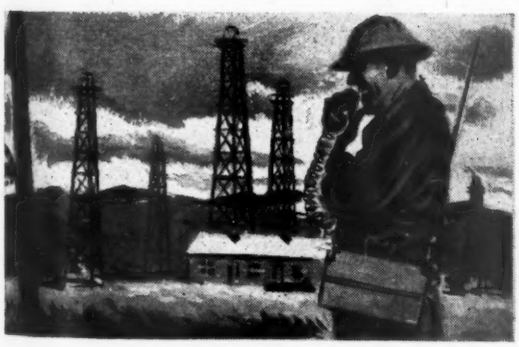

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Pipe Line Contractors

Williams Brothers Corporation of Canada, Edmonton, Alberta, Canada, expects to complete the middle of October 176 miles of 10-in. and 46 miles of 8-in. pipe line for Trans-Northern Pipe Line Company. The 10-in. pipe is being laid between Kingston, Ontario, and Montreal, Quebec, and the 8-in. between Farrens Point and Ottawa, Ontario. The field office is at Lancaster, Ontario. G. S. Conners is superintendent, John R. Purdy office manager, and Dan Maloney master mechanic.

George Tucker Pipe Line Construction, P. O. Box 1987, Odessa, Texas, is constructing a gathering system near Goldsmith, Texas, for Phillips Petroleum Company. The job will total 55 miles of 6-in. through 24-in. pipe and is being handled out of the home office by R. E. Pigg as superintendent and Cliff Brownell office manager.

For Magnolia Pipe Line Company, 14 miles of 3 and 4-in. pipe is being laid from the Sweetwater, Texas, pumping station south.

Somerville Construction Company, Ada, Michigan, is laying 3200 ft of 34-in. pipe from Panhandle Eastern Pipe Line Company's Tuscola, Illinois, station to National Petro-Chemical Corporation plant. O. P. Hiner is superintendent.

Engineering-Construction Company, 402 North Cheyenne, Tulsa, Oklahoma, got underway the middle of September on 50 miles of 10-in. pipe line for Kansas-Nebraska Natural Gas Company from Ogallala to North Platte, Nebraska. The field office is at the latter point. Lee Vaughn is general superintendent, Lloyd Evans spreadman, and V. L. Bethel and Dave Wells office managers. The coating has been sub-contracted to Secrest Pipe Coating Company.

Ray L. Smith and Son, Inc., Hazlett Building, El Dorado, Kansas, have contracted to install seven river crossings for the Standard Oil Company of Indiana on its products line from Kansas City, Missouri, to Dubuque, Iowa. Two spreads are working.

Will start 20 miles of 30-in. October 1 for Natural Gas Storage Company of Illinois between Dwight and Herscher, Illinois. Dewey Whitworth will be spread superintendent and Don Marley office manager.

J. L. Cox and Son, Raytown, Missouri, are stringing 340 miles of 22-in. pipe between Salisbury, Missouri, and Schrerville, Indiana, on the Sinclair Pipe Line Company system. Other jobs for Sinclair are 400 miles of 8 and 12-in. from Shannondale station to Wood River station, and 600 miles of 8, 12, and 14-in. pickup from Manuel station, Oklahoma, to Independence, Kansas.

Jayhawk Construction Company, P. O. Box 419, Great Bend, Kansas, is laying 44.5 miles of 4-in. through 16-in. pipe line for Kansas-Nebraska Natural Gas Company from a point near Lakin, Kansas, to near Garden City, Kansas. The work was approximately 60 per cent completed the middle of September.

Jim J. McCormick Company, Box 2014, Wichita Falls, Texas, is taking up 33 miles of 8-in. and 10 miles of 6-in. between Purcell and Shawnee, Oklahoma, for Magnolia Pipe Line Company. Between Addington, Healdton, and Fox Field, Oklahoma, 25 miles of the 8-in. will be re-laid. The field office is at Purcell. T. C. Pierce is superintendent and Lloyd Killough office manager.

Trojan Construction Company, 1416½ North Robinson, Oklahoma City, Oklahoma, is taking up and reconditioning in part 400 miles of 8, 10, and 12-in. pipe in Indiana and Ohio for the Ohio Oil Company. The job was subcontracted from Conyes Construction Corporation. Charles T. "Swede" Tillotson is general superintendent. Two spreads are being employed. One spread is working out of Clinton, Indiana. Will Robinson is office manager. "Slim" Deavers is in charge of the crew having its headquarters at Bluffington, Indiana. R. W. Wells is office manager.

Canadian-Parkhill Pipe Stringing, Ltd., Toronto, Canada, is stringing 469 miles of 24-in. for Trans-Mountain Oil Pipe Line from Acheson, Alberta, to Burnaby, British Columbia. Contractors: Comstock-Midwestern, Ltd., and Canadian Bechtel. Superintendent, Jack Williams.

360 miles of 10-in. for Trans-Northern Pipe Line Company from Hamilton, Ontario, to Montreal, Quebec, Canada. Contractors: Sparling and Davis Company, Ltd., and Williams Brothers.

Mannix, Ltd., Calgary, Alberta, Canada, has in progress 224 miles of 24-in. pipe line for Trans-Mountain Oil Pipe Line Company, extending from Blue River to Coquihalla Pass, British Columbia. The field office is at 412 Victoria Street, Kamloops, British Columbia. C. P. Baker is project manager, "Curley" Wilkerson spreadman, and H. Eisler office manager.

Panama-Williams Company, 403 Melrose Building, Houston, Texas, is laying 38 miles of 20-in. pipe line for West Texas Gulf Pipe Line Company, from Wortham, Texas, east to Trinity station; and 20 miles of 26-in. into Livingston. The field office is now at Crockett, Texas. M. E. "Panama" Shiflett is general superintendent, Gene Coulter spreadman, "Cooney" Shiflett assistant spreadman, and Ernest Smith office manager.

River Construction Corporation, 6100 Camp Bowie Boulevard, Fort Worth, Texas, the latter part of September completed the work it has been doing for United Gas Pipe Line Company in Texas and Louisiana.

Comstock Midwestern, Ltd., 206 Laird Drive N. Leaside, Ontario, Canada, has been at work since late in May on 472 miles of 24-in. pipe line for Trans-Mountain Oil Pipe Line Company, which will extend from Edmonton, Alberta, to Vancouver, British Columbia. The central project office is at 3390 Kingsway, Vancouver. The telephone number is Dexter 5511. C. C. Bledsoe is project manager, Charles Rathgeb, Jr., assistant project manager, M. T. "Bill" Wilhite general superintendent, A. T. Tolbert assistant superintendent, and Mike Seville office manager.

The three spreads are located as follows:

Jasper, Alberta: John Work spreadman, D. E. Anderson office manager, and Herb Allen master mechanic.

Valemount, British Columbia: E. H. Work spreadman, N. O. Boies office manager, and Ralph Burnett master mechanic.

Chilliwack, British Columbia: Herschel Howard, superintendent.

Oklahoma Pipe Line Constructors, 6612 Hines Boulevard, Dallas, Texas, is still waiting on pipe to complete its section of the Rancho Pipe Line Company. Of a total of 68 miles of 24-in., 18 miles remained to be laid when the job shut down. This is a joint venture with Houston Contracting Company. The 68-mile section is from Shell's refinery at Pasadena, Texas, west to the Brazos River.

The 116 miles of 30-in. for Tennessee Gas Transmission Company, three loops between Refugio and Cleveland, has been completed.

Vaughn and Taylor Construction Company, P. O. Box 1351, Wichita Falls, Texas, is laying a gathering system in the vicinity of Odessa, Texas, for Phillips Petroleum Company, totaling 268 miles of 2-in. through 30-in. pipe. D. D. Vaughn is superintendent and Clark Sayles office manager.

Holder Construction Company, Snyder, Texas, is constructing a gathering system in Borden and Howard counties, Texas, for the Reef Field Gasoline Corporation. It will consist of approximately 100 miles of 3-in. through 12-in. pipe. C. O. Holder, Jr., is superintendent and L. Arnold office manager.

Bishop and Lock Construction Company, 1018 Magnolia Building, Dallas, Texas, has contracted to lay 42 miles of 8⅝-in., 4 miles of 6⅝-in., and 7 miles of 4½-in. pipe for the Texas-New Mexico Pipe Line Company. The lines will extend the existing sweet crude gathering facilities of the company in the Lovington pool in southeast Lea County, New Mexico, to the Saunders area of northwest Lea County. The field office is in the Lister Building at Lovington, New Mexico. Howard Laquey is superintendent and M. E. Williams office manager. The work is underway.

The spread laying 60 miles of 3, 8, and 10-in. pipe from the Oletha field to Waco, Texas, for Ebasco Services Incorporated, has moved its field office from Groesbeck to Waco. This job is more than half completed. Johnny McMahan is superintendent and W. H. Bond office manager.

Fulton and Brodie Construction Company, P. O. Box 2064, Amarillo, Texas, have 142 miles of 20-in. on the Platte Pipe Line Company system, the section between Holdrege and Odell, Nebraska.

Rumsey Brothers Pipe Line Construction Company, 4039 North Broadway, Wichita, Kansas, has 100 miles of Platte Pipe Line Company project, the section is between Marysville, Kansas, and St. Joseph, Missouri. The field office is at Hiawatha, Kansas. Myrl Rumsey is superintendent and Glenn Stitt office manager.

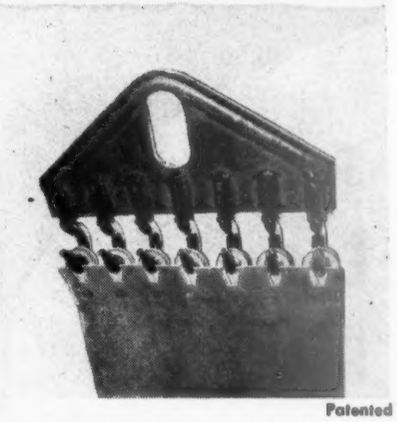
H. L. Gentry Construction Company, 921 East Michigan Avenue, Jackson, Michigan, has moved its field office to Ganville, New Jersey, from where work is going forward on the 75 miles of 16-in. being laid for Buckeye Pipe Line Company between Mecungie, Pennsylvania, and Linden, New Jersey. F. K. Morris is general superintendent, John Schafer office manager, and Merle Hepler master mechanic.

From Taunton to North Syracuse, New York, 25 miles of 10, 12, 16, and 24-in. pipe is being laid for Niagara Mohawk Power. Laverne Curtis and Robert Cantrell are spread foremen.

P. & S. Constructors, Inc., Cape Girardeau, Missouri, is laying 276 miles of 14-in. pipe line for Shell Oil Company from Wood River, Illinois, to East Chicago, Indiana. The field office is at Gibson City, Illinois. A. G. "Arkie" Hobson is superintendent and V. E. Connor office manager.

Piggott Construction Alberta, Ltd., Edmonton, Alberta, Canada, has in progress 57 miles of 6-in. pipe line for the Saskatoon Pipe Line Company, Ltd.

SUPERIOR BELT SLING



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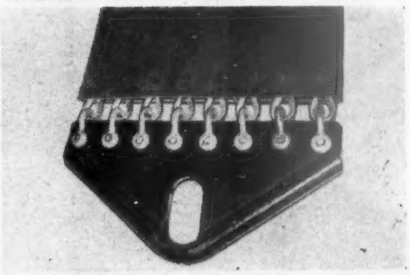

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Pipe Line Contractors

Tulsa-Williams Company, National Bank of Tulsa Building, Tulsa, Oklahoma, expects to complete early in October 143 miles of 10, 24, and 26-in. pipe line for Algonquin Gas Transmission Company in New York, New Jersey, and Connecticut. The central office for this project is at Danbury, Connecticut. R. L. Buck is general superintendent, R. E. Higgenbotham office manager, and George Littlejohn project engineer. Spread headquarters are as follows:

Denville, New Jersey— O. R. Mitchell superintendent and Paul Mackie office manager.

Suffern, New York—Whitey Martin superintendent and Sam Davis office manager. George Allen is superintendent of a second crew working out of this office.

Waterbury, Connecticut—T. E. Davis superintendent and Walt Smeltz office manager.

Williams Brothers Company, National Bank of Tulsa Building, Tulsa, Oklahoma, is doing considerable work in the southeastern part of the United States and has established offices at Atlanta, Georgia (Telephone 47-4341) and Charlotte, North Carolina (Telephone 6-3418). Buddy Franks is general superintendent, Bob Folk and Joe Breedlove office managers, and E. U. Mahaffey and Brownie Young general foremen. Seven crews are in the field, installing distribution lines at Chamblee and Atlanta, Georgia, and Mt. Holley, North Carolina; 6-in. transmission line near Williamston, South Carolina; 2, 4, and 6-in. transmission and distribution lines at Gastonia, North Carolina; 4-in. transmission line near Burlington, North Carolina, and a products terminal for The Texas Company at Doraville, Georgia.

Anderson Brothers of Venezuela, C. A., 6300 Navigation Boulevard, Houston, Texas, is laying a crossing of the Gulf of Coro for Creole Petroleum Corporation. Approximately 80,000 ft of 26-in. pipe will be installed. The field office is at Las Piedras. "Red" Goode is superintendent.

J. E. Young Pipe Line Contractor, Inc., 931 East Rosecrans Avenue, Los Angeles, California, is laying 41 miles of 8⅝-in. pipe for Southern California Edison Company between Santa Fe Springs and Etiwanda. The work is expected to be completed the middle of October. Jack Cook is project superintendent and Ronny Cook spread superintendent.

L. E. Farley, Inc., 2609 Sunset Boulevard, Houston, Texas, has contracted to lay 64 miles of 16-in. pipe line for Interstate Oil Pipe Line Company, from Morgan City to Baton Rouge, Louisiana. Due to delayed pipe shipments this work probably will not get started until after the first of the year.

Missouri Valley Dredging Company, 222 Williams Street, Omaha, Nebraska, is installing a 3900-ft, 22-in. crossing of the Illinois River near Havana, Illinois, for Sinclair Pipe Line Company. Virgil Bull is superintendent and G. W. Van Horn office manager.

Harford Brothers Pipe Line Construction Company, Emporium, Pennsylvania, is still shut down, having run out of pipe, on its work for Lake Shore Pipe Line Company. The section consists of 75 miles of 10-in. from Cochranton, Pennsylvania, to Ashtabula, Ohio, then west to Fairport Harbor, Ohio. The field office is at Lineville, Pennsylvania. A. M. and W. E. Harford are in charge. Earl Dell is spreadman and W. Q. Harris office manager.

R. H. Fulton and Company, P. O. Box 1526, Lubbock, Texas, has recently contracted to lay 76 miles of 20-in. for the West Texas Gulf Pipe Line Company. The section will be from Longview, Texas, west.

Work has begun on the 55 miles of 8-in. being laid for Pioneer Pipe Line Company in the vicinity of Salt Lake City, Utah. The field office is at that point with Jerry Nash spreadman.

This contractor also is laying a total of 433 miles of the Platte Pipe Line Company system, from Casper, Wyoming, to Holdrege, Nebraska. The field office is at North Platte, Nebraska, with A. A. Carrigan superintendent.

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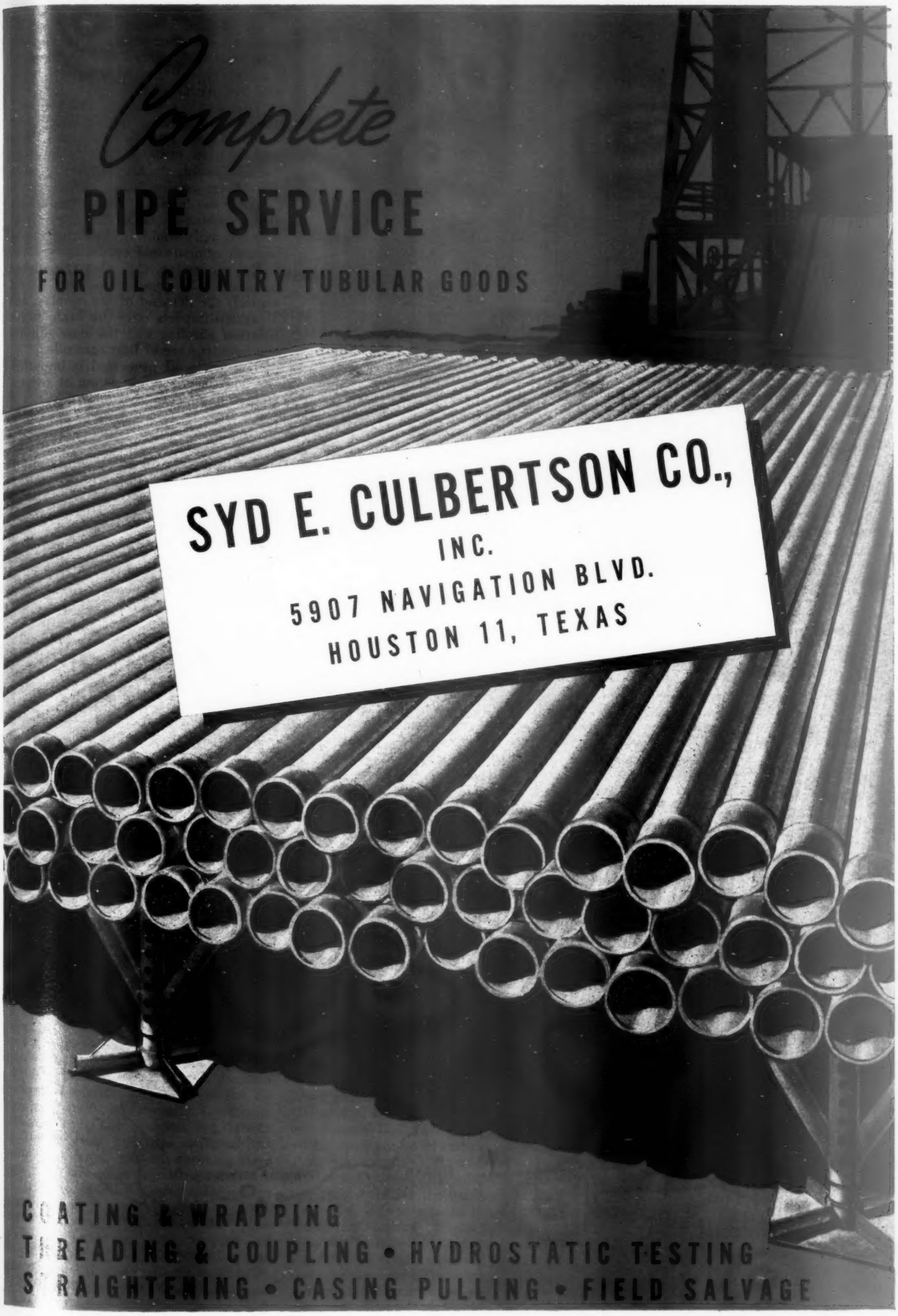
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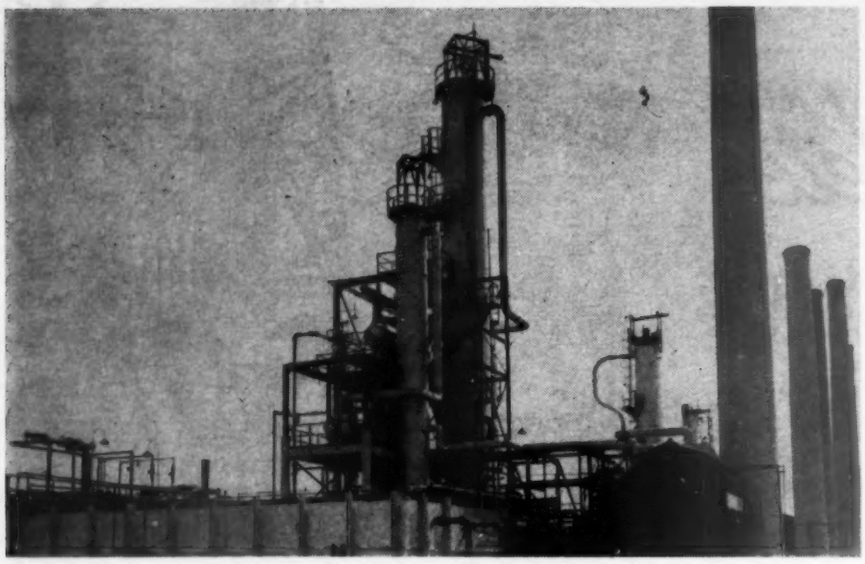


View of distillation unit at Lateja refinery near Montevideo.

URUGUAY

ING. ALFREDO D. LEVRERO*

THE present refining capacity of the refinery of Administracion Nacional de Combustibles Alcohol and Portland, in Lateja, the only one in Uruguay, is 25,000 bbl per day.

This amount has been reached with the start of a new topping unit, which has been operating since August 1, 1950, and the topping and cracking units (this latter operating as topping unit), which have been running since 1937.

With the new unit was mounted a little vacuum plant with a capacity of 750 bbl daily enabling the expansion of asphalt cements and cut-backs.

By processing the above-mentioned amounts it is possible to meet almost entirely the demand of the country, and Uruguay imports only the high octane aviation gasoline and the base oils for the manufacture of lubricant oils.

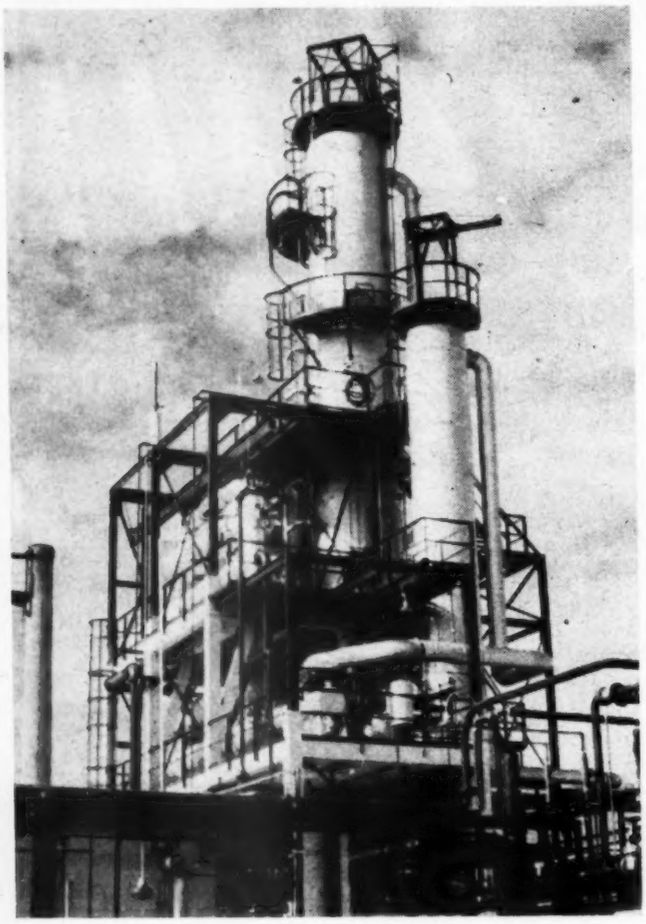
The crude oil processed is imported, the sources of supply being at present Venezuela, Arabia, Ecuador, Chile, and Peru, in decreasing order as far as figures are concerned.

Referring to petroleum exploration, a geophysical† program involving gravimetric and magnetometric surveys in the northwestern area of the country has been in operation during 1951. The plan for 1952 is to continue and enlarge this program. * * *

* Assistant general manager, Administracion Nacional de Combustibles Alcohol y Portland.

†Conducted by Exploration Surveys International, Inc.

Another view of distillation unit.



EXCLUSIVE

Desk and Derrick directors and officers for 1953 are: Ruth Palmer, Casper, Wyoming; Doris Whiteside, Dallas, Texas; Lamont Tofte, Wichita Falls, Texas; Frances Crawford, Vicksburg, Mississippi; Irene Stimson Cox, San Antonio, Texas; Margaret Neff, Jackson, Mississippi; Anne Curren, Tulsa, Oklahoma; Eleanor Crockett, Calgary, Alberta, Canada; Carol Eberhart, New York City; Lillian Tucker, Shreveport, Louisiana; Maxine R. Hacke, Tulsa. Not shown is Florence M. Hopkins, Pasadena.

Oil Women Spud In Own Organization

MARY MORRIS LYMAN*

"The men won't believe this."

Mrs. Lee Wilson Hoover, then president of the National Association of Desk and Derrick Clubs of North America, smiled as she commented on another of many unanimous decisions at the first annual convention of the clubs.

For two full days more than 1000 members of the different clubs throughout the United States and Canada met at the Shamrock Hotel, Houston, Texas, to set up a permanent constitution for the national association, held special study courses on different phases of the association, and were guests of various oil and supply companies at two luncheons and an outdoor dinner. The meeting began with a welcome by Mayor Oscar Holcombe and closed with a speech by the president of Plymouth Oil Company, and chairman of the National Petroleum Council, Walter S. Hallanan. Other speakers were Inez Awty Schaeffer, founder of the Desk and Derrick Club, and Russell B. Brown, general counsel, Independent Petroleum Association of America.

The organizational work went smoothly except for an occasional lapse (like "I second the emotion") and it was hard to believe that many of the delegates belonged to no other clubs. Much credit for this goes to Camella Bustetter, chairman of the business and rules committee.

Mrs. Schaeffer, who first got the idea for an association of women in the oil industry in New Orleans, Louisiana, pointed out to her audience the danger of letting club activities drift in the wrong direction, and of devoting time needed in the office to club matters.

"In June, 1951, we were able to turn over to Lee Wilson Hoover and her capable Board of Directors the Association of Desk and Derrick Clubs of North America," Mrs. Schaeffer reported. "In this connection I would like to point out to you the danger of allowing our national organization to become too powerful. It is the local clubs and their problems that should hold our attention.

"We have a great responsibility to the industry. The Desk and Derrick Club has had phenomenal growth. This has been due largely to the paternalistic assistance of our employers and the industry as a whole. This assistance has been based not so much on what we have already accomplished as on what the industry looks for in the future from us in the way of improved industrial relations and improved public relations.

"If we allow our club activities to interfere in any way with the job for which we are being paid, we are hurting Desk and Derrick. If an employer asks his secretary or accountant to do something for him and he discovers she is working on Club matters, I am sure his enthusiasm for Desk and Derrick will be dampened.

"Women have been justifiably criticized in offices for being too emotional, resenting criticism, allowing petty jealousies to arise, taking long coffee and lunch periods, using the telephone unnecessarily, and jumping from one job to another without any feeling of responsibility or obligation to employers.

"I urge you to practice self-examination and set as good an example as you possibly can in your office. If you do, our horizons will not only be extended, they will be unlimited."

Russell B. Brown told the oil women ". . . . you are an important integral part of this industry's economic and industrial activities. This industry provides a great field for the professional career women. It was among the first of the large industries to avail itself of the career woman as chemists, refining engineers, geologists, petroleum engineers, etc. In the field of research for the benefit of the human race your role is important. You have organized and administered our office personnel to a large extent. Women own a great proportion of our capital stock."

"Molly Pitchers of the oil industry," is the term Walter S. Hallanan used to describe members of the Desk and Derrick Club. "What Molly Pitcher was to our country in the war days, you are to the oil and gas industry today. As Molly Pitcher went down in history as the inspiring heroine who carried sustenance to the soldiers and even manned the guns when necessary, so shall it be noted that you will have aided and augmented our constant fight to put forth the best efforts of the petroleum industry in meeting the greater responsibilities that a new and better day brings."

Hallanan added that "in the oil industry there may be price ceilings, but there are no capacity ceilings; there is always room at the top. It is an industry that is big in past, present, and in the future. You can feel that you are engaged in serving your world through the making of contributions adding up to service and progress that have no comparison anywhere."

New officers and directors were elected at the convention, and will take office in January, 1953. They are: Margaret Neff, Dixie Geological Service, president; Frances Crawford, Brunini, Everette, Gantham, and Quin, secretary; Lamont Tofte, Texas Seismograph, treasurer; Irene Stimson Cox, Panhandle Producing, first vice president; Anne Curren, Ohio Oil, second vice president. The following regional directors were named: Carol Eberhart, The Texas Company, Region 1; Maxine R. Hacke, Warren Petroleum, Region 2; Lillian Tucker, Pan American Production, Region 3; Ruth Palmer, Rocky Mountain Oil and Gas Association, Region 4; Florence M. Hopkins, United Geophysical, Region 5, and Doris Whiteside, Texas Mid-Continent Oil and Gas Association, Region 6.

*Assistant Editor.

News

Gulf and Atlantic May Be Added to Government Suit

Two more oil companies, Gulf Oil Company and Atlantic Refining may be added to the list of companies now under investigation by the Justice Department to determine if they have over-charged the U. S. Government on oil shipments delivered under the foreign aid program. Shipments involved were made between May, 1949, and August 31 of this year, and were delivered to from Kuwait to European countries. Most of the oil, the Mutual Security Agency reported, was handled by Gulf Oil, and smaller shipments were made by Atlantic and Socony-Vacuum.

Other companies already involved in the government suit are Standard Oil (New Jersey), Standard Oil California, Socony-Vacuum Oil, and The Texas Company.

Imports Dip Slightly

Imports of foreign oil into the United States for the week ending September 16 averaged 860,600 bbl daily, slightly under the 895,800 bbl daily imported the week before, according to a report issued by the American Petroleum Institute.

Below are figures for the week of September 13, and the four weeks prior to this date.

Week ended	Crude oil	Residual oil	Others	Total
August 16.....	515,700	205,300	45,200	767,200
August 30.....	619,500	155,500	56,200	831,200
September 6...	612,300	221,600	6,700	895,800
September 13..	611,900	231,400	17,300	860,600

Hines Baker Speaks at Texas Mid-Continent Meet

Hines H. Baker, president, Humble Oil and Refining Company, Houston, is one of the panel of speakers scheduled

Hines H. Baker

for the 33rd annual meeting of Texas Mid-Continent Oil and Gas Association at Hotel Texas, Fort Worth, October 14-15.

Baker's address, "Statesmanship in Industry," will be delivered on the second morning of the meeting, Charles E. Simons, association executive vice president, announced.

Head of the state's largest petroleum company since 1948, Baker is a Phi Beta Kappa from the University of Texas, where he was graduated with a law degree in 1917, joining the law department of the Humble two years later.

Export Figures Out

The Petroleum Administration for Defense has issued the following summary of U. S. exports of major petroleum products. Figures are for the weeks ending August 1, 8, 15, and 22. Given in thousands of barrels daily, figures include products exported by tanker and barge movement only.

Week ending	Avgas*	Motor gasoline	Kerosine	Distillate	Residual	Total
August 1...	67.8	32.4	41.8	105.5	87.7	335.2
August 8...	52.5	10.3	13.5	41.3	56.1	173.7
August 15..	31.3	5.9	33.9	80.7	42.5	194.3‡
August 22..	2.5	19.1	3.8	59.6	41.9	126.9

*Avgas is partly estimated and includes all methods of shipment.
‡Revised.

Iran Will Let World Court Set British Compensation

Premier Mossadegh of Iran has announced that he is willing to let the World Court rule on how much compensation Britain should receive for installations, taken over by Iran. Earlier Mossadegh had rejected settlement proposal made by President Truman and British Prime Minister Churchill that called for submission of the question to the Court. Iran is prepared to pay compensation only for the properties, Mossadegh added in his announcement.

Even this decision on the part of Mossadegh left little hope that a settlement would be reached in this manner, because Britain has made clear she will not accept compensation on properties alone, without settlement of additional claims.

Iran still hopes the World Bank will consider its request for a loan of between $19 and $21,000,000 to help get the country back toward solvency.

W. Alton Jones, president of Cities Service Oil Company, who has been in Iran holding a series of conferences with Mossadegh, has announced he is considering sending advisory technicians to Iran. He added his company may eventually purchase Iranian oil. He emphasized that no agreement or deal had been made with Mossadegh, but added that the contemplated program would not depend upon any settlement of the Anglo-Iranian dispute.

Amerada to Build Large Reclaiming Plant

Amerada Petroleum Company has announced its plans to build a multi-million-dollar plant to reclaim natural gas produced from its oil wells in the Williston Basin, North Dakota. Amerada's Williston holdings include the Beaver Lodge and Tioga fields, both in North Dakota, where gas now flowing from producing oil wells is being burned off.

Albert Jacobsen, president of Amerada estimated the new plant will cost between $10,000,000 and $20,000,000 and will be situated as close as possible to the center of the producing area. The plant will extract gasoline and sulfur from natural gas. Jacobsen did not predict when the plant will begin, as sufficient data on its Williston resources must be obtained first.

Kilgore Jube-OIL-Lee Notes Oil Progress

Contributions oil has made to East Texas are being celebrated in a Jube-OIL-Lee October 14, 15, and 16 in Kilgore, Texas. Events during the three-day

Marjorie Ann Brown, of Kilgore College's famed Rangerettes, sits on Christmas tree near discovery well of East Texas oil field. With her is W. S. Morris.

celebration include the coronation of an Oil Queen, a Queen's Ball, tours of oil installations, an old timers' reunion, and a parade. W. S. Morris of Kilgore, manager of East Texas Salt Water Disposal Company, is general chairman.

A granite marker at L. D. Crim No. 1, the discovery well in the Kilgore area, will be unveiled in special ceremonies. Humble Oil and Refining Company, operator of the well, has erected the marker, which is inscribed with the history of the well.

Miss Dolores Russell will be crowned Oil Queen. Texas Railroad Commissioner William J. Murray, Jr., and Erle P. Halliburton, chairman of Halliburton, chairman of Halliburton Oil Well Cementing Company, Duncan, Oklahoma, and the famous Rangerettes are on the program.

PAD Urges Home Owners To Fill Fuel Tanks at Once

Home owners on the East Coast have been warned by the Petroleum Administration for Defense that unless yields of distillate such as kerosine, home heating oil, and diesel fuel are stepped up during the next few months, they will feel a shortage of the products next winter.

PAD urged users of home-heating oil to fill their tanks just as quickly as possible to help avert possible shortages in their area this winter. Deputy Petroleum Administrator J. Ed Warren reported that the petroleum industry is trying to help out in this situation as much as possible. He said PAD had calculated that of the crude oil going to refineries about 31.8 per cent should represent distillate output. He said the yield deficiency could result in a shortage of approximately 45,000 bbl a day during the winter months.

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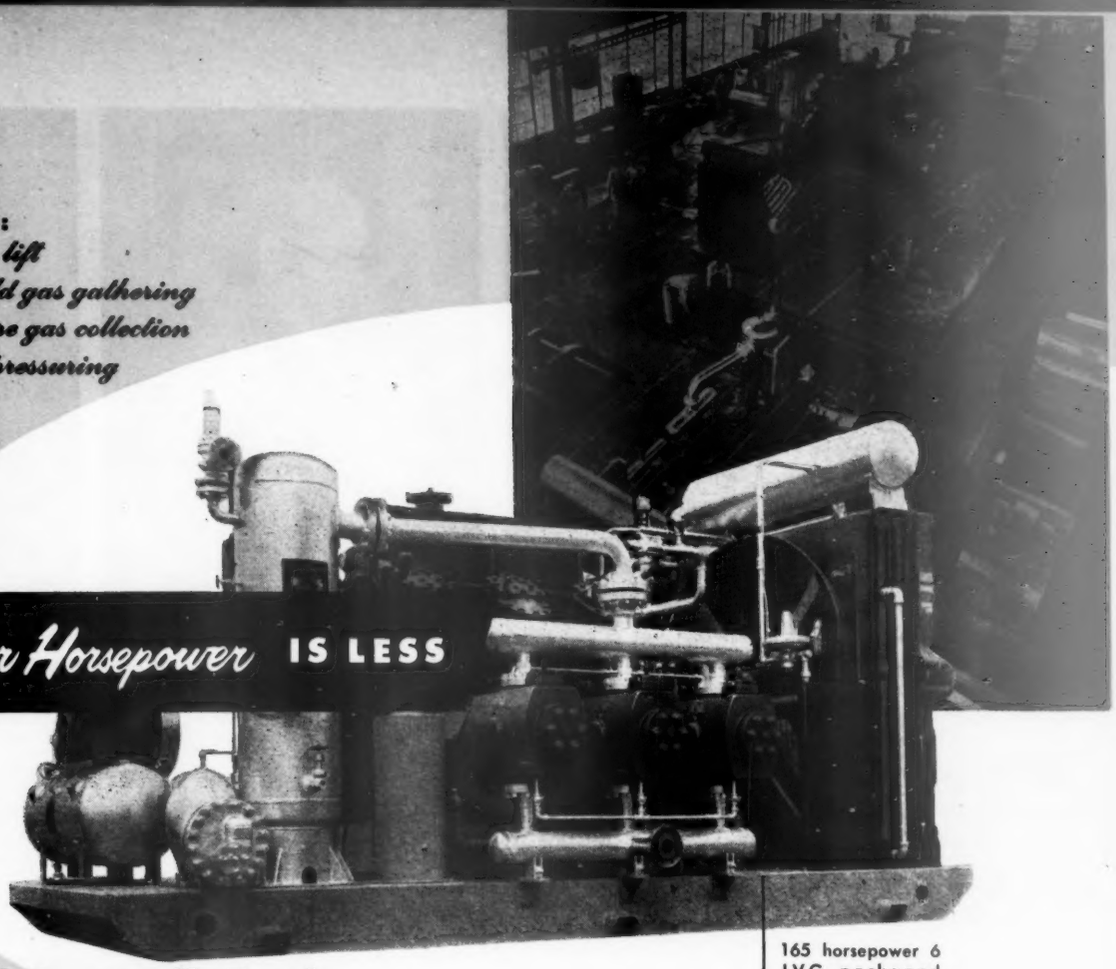

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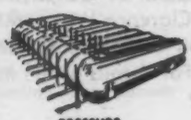
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Purchasing Agents Association, at a recent meeting in Tulsa, Oklahoma, made a gift presentation to R. C. Baker, Sr., president of Baker Oil Tools, hosts at the meeting. H. M. Cosgrove, retired secretary of the Association is shown presenting the gift. Center, R. C. Glover, Tulsa division sales and export engineer, Baker, addressed the meeting, and R. W. Henderson, right, vice president and assistant general manager for Baker spoke of the achievements of the meeting.

FPC Sharply Criticized For Its Quest for Power

A resolution passed by an overwhelming majority of members of the Interstate Oil Compact Commission has officially called up the Federal Power Commission to "cease its constant quest for additional unlawful power."

Meeting in Banff, Alberta, Canada, members of the IOCC were especially critical of FPC's action in the Northern Natural Gas Company case when it refused to recognize the Kansas Corporation Commission's increase in minimum prices to gas producers in the Hugoton gas field. The Compact declared that the FPC should cooperate with the state in its attempt to conserve natural resources, rather than ignore state price-fixing at the wellhead. The Oklahoma Commission had ordered an increase in minimum prices to gas producers in the Hugoton field.

Israel Will Get Money For Purchase of Crude Oil

A $6,000,000-per year agreement for the purchase of crude oil and refined products has been reached by the government sponsored Israel Fuel Corporation and a threefold finance group—American Israel Petroleum Corporation, Overseas Discount Corporation, and American Palestine Trading Corporation. With the $6,000,000 placed at the disposal of the Israel Fuel Corporation for oil and petroleum products, this company can market about 200,000 tons (1,400,000 bbl) yearly.

Also from Israel comes word that parliament has passed a new oil law by a large majority authorizing prospecting for oil in that country. No monopoly concessions, under the regulations, will be given any one firm and equal opportunity will be afforded both foreign and domestic companies.

The new law provides that for exploration purposes the country will be divided into four districts, and all mineral rights will be owned by Israel.

OPS Rejects Pleas for Higher Prices on Gas, Oil

The Office of Price Stabilization has turned down recommendations for higher price ceilings on natural gas produced in Texas by Stanolind Oil and Gas Company and Continental Oil. The plea was turned down by ex-price chief Ellis Arnall, in one of his last official acts, even though a special board of review, which had been appointed to study the case, had recommended raising the price from 10 cents per 1000 cu ft to 11½ cents.

This was the second time Stanolind and Continental had lost their appeal to get higher ceilings on natural gas produced from the Woodlawn field in Harrison County, Texas. The two companies appealed from an Office of Price Stabilization order setting the 10-cent ceiling. They contended that negotiations with Mississippi River Fuel Company for the higher price of 12 cents per 1000 cu ft were already under way before prices were frozen January 26, 1951.

Pennsylvania Grade crude oil producers received a like decision from OPS recently. Their plea for a hike in the $4.25 per barrel ceiling price on their petroleum was rejected, and Tighe E. Woods, price stabilizer, notified R. J. Brennan, chairman of the Pennsylvania Oil Producers Committee that if the committee had further evidence to submit in support of its request it would be considered.

The Producers Committee announced it has made no plans regarding a future course of action, adding that it had submitted all the information available and all OPS had asked for.

Fishing off the Island of Catalina are: Henry W. Pullman, Baker Oil Tools; Mrs. Pullman; Mrs. Clarence White, Mrs. Thelma Irby, Mrs. Nina Murren, Clarence White, Oil Well Manufacturing Corporation; and R. E. Irby, Colombian Petroleum. (For details of the fish story see Petrolic Personalities, Page A-8.)

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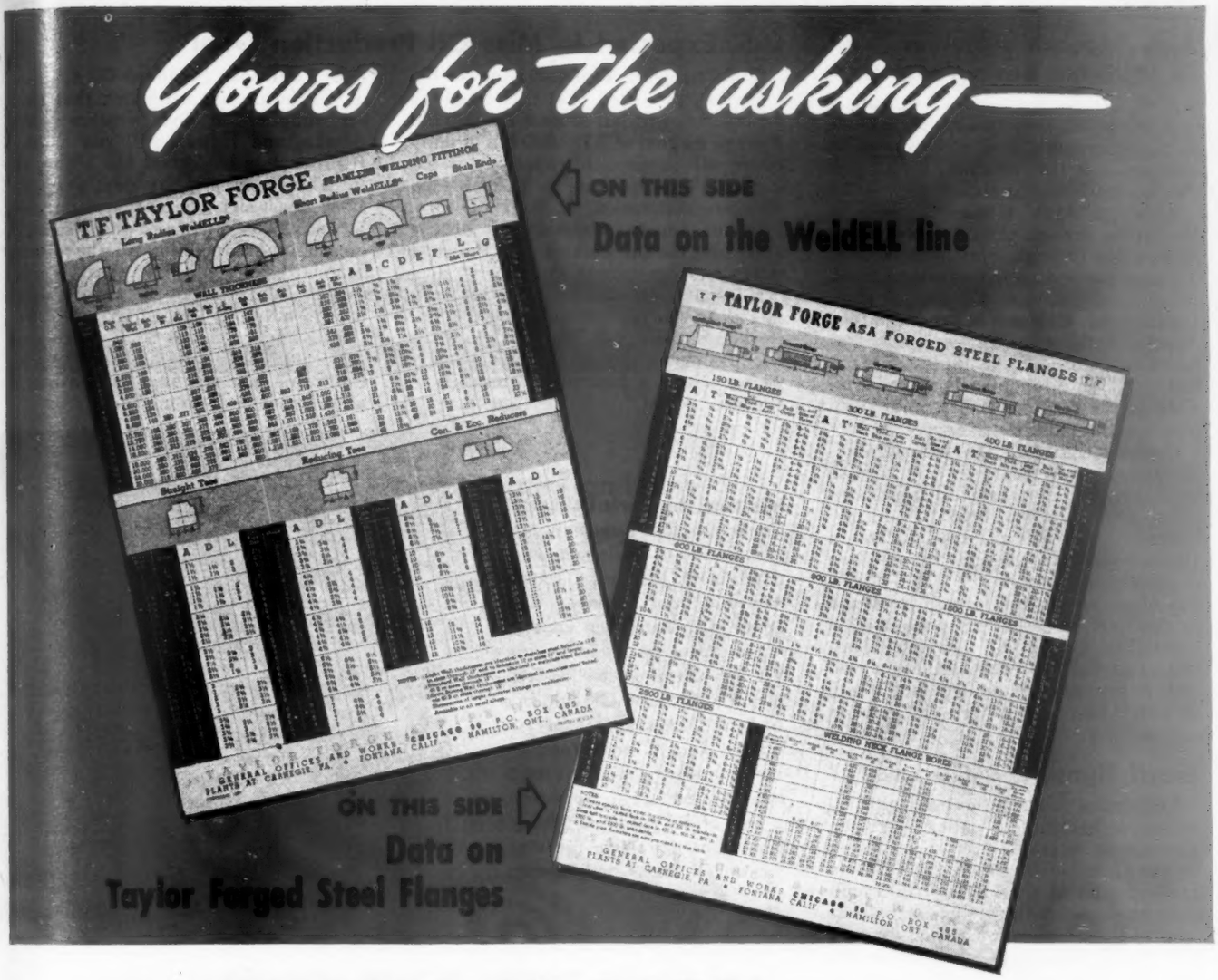
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Ajax Expands Activities To Williston Basin Area

Ajax Petroleums Limited announces expansion of its interests to include participation with three other Canadian companies in the Montana, U. S., portion of the Williston Basin.

Although Ajax' producing wells at Morinville are standing capped ready to pipe gas through Ajax' own $1,700,000 pipe line system to Canadian Chemical Company's new Edmonton plant (affiliate of Celanese Corporation of America), the Canadian company has taken on a 15 per cent interest in 120,000 acres in Montana. Partners with Ajax in the deal are Albermont, Transera, and Eramont Petroleums.

Central feature of the Ajax group's Montana spread is acreage straddling the Baker-Glendive or Cedar Creek Anticline, where Texaco, Shell, Frobisher-Federated, and others have indicated a 100-mile-long production trend. Two producers there are in the 6000-bbl-per-day class, among the largest yet found in the west, and there is no proration there. The Ajax group has offset quarters to an Empire State Hathaway well and a Frobisher-Federated well, both of which have found some oil and are still drilling.

Brazil Signs New Oil Law

Legislation to make the petroleum industry a half-billion dollar Brazilian government monoply has been passed by the Chamber of Deputies in Rio de Janeiro. Aim of the bill will be eventually to close out all foreign interests as soon as their concession period expires. A national monoply was expressly declared on: Research and production, refining of both national and imported oil, water transport of Brazil's oil, and its products and pipe line transport, regardless of the origin. Present transports of oil and existing refineries are exempted until concessions run out.

Final senate approval is necessary but there is little doubt it will be given. The bill provides the monoply will be carried out by the national petroleum council, as the top policy organ, and the Brazilian Petroleum Corporation.

Tariffs Cut on Imported Venezuelan Crude Oil

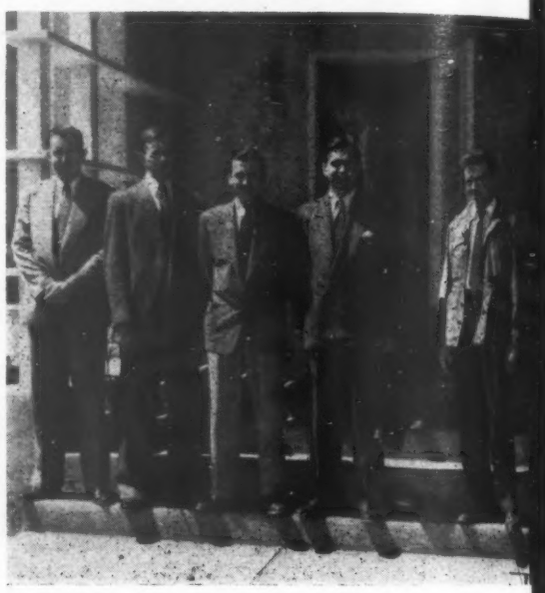
The United States and Venezuela have signed an agreement lowering tariff on Venezuelan oil ranging up to 50 per cent reductions. The cut was made, according to an announcement by President Truman, in return for extensive tariff concessions on American exports to Venezuela. Reduction in tariff will apply not only to Venezuela but to all other oil countries as well.

Under the agreement, the U. S. will cut duties on crude petroleum, top crude oil, and residual fuel oil to 5½ cents a barrel on oil with an API rating of less than 25 deg and to 1½ cents a barrel on oil with more than 25 deg rating. Duty was formerly 10½ cents on all imports amounting to less than 5 per cent of U. S. production, and 21 cents on imports exceeding that total.

U.S. Expected to Miss Oil Production Goal

The Petroleum Administration for Defense has predicted that this country's oil industry will fall at least 113,000 bbl short of its goal of 7,722,000 bbl of daily crude oil production capacity by the end of 1952. Speaking to the CIO Oil Workers convention, E. Earl Mattern, assistant deputy administrator of the PAD told the oil workers that the steel strike and consequent shortage of steel had lost an estimated 5000 new oil wells this year. He added that the refinery workers' strike last May may have a serious impact on the East Coast next winter where a lack of heating oils is expected.

In California, Standard Oil Company of California has estimated that crude oil supplies in five western states, Alaska, and Hawaii will run short of requirements by 59,000 bbl a day, and by 63,000 bbl per day next year. The West Coast shortage was brought about by an increased demand and a small increase in producibility in the district, Standard declared. The Korean War has further aggravated the shortage by heavy military demands. The West Coast's independence from outside supply is thought to be over by Standard California, and the area will have to be a net importer from now on.



Visiting Imperial's Edmonton, Canada, refinery recently were: J. R. Caddy, A. J. Rogers, sales department, Vacuum Oil Ltd. of Australia; Jack Menneer, drilling editor, The Petroleum Engineer; M. A. Wood, accounts department, Vacuum Oil of Australia; Eric McVeity, Imperial Oil Ltd., and A. Patton, Imperial refinery. Caddy, Rogers, and Wood recently spent a week at the Imperial refinery in Edmonton, as a part of a 5-month tour they are making of petroleum facilities in the United States and Canada.

Cartel Charges Harmful to Small Firms, Craig Claims

Earle M. Craig, president of the National Petroleum Association, declared recently that the Federal Government's oil cartel charges are not a matter of cheer for small businesses but rather a "cause for fear that a similar attack may be made upon us."

Craig, president of Freedom-Valvoline Oil Company, addressed the opening session of the NPA's Golden Anniversary meeting in Hotel Traymore, Atlantic City, New Jersey. Commenting on increased regulation by government in the last decade, he declared:

"The most recent example of Federal government intrusion in the oil industry has occurred in the last month when with great fanfare some of the larger oil companies are accused of being members of an international conspiracy to dominate world oil trade.

"That is apparently part of a shrewd propaganda technique that this attack is being made for the benefit of small business; however, we of the smaller companies of the industry are not cheered by this act of Government because we recognize that an unjust attack on one company or a group of companies does not help us, but gives cause for fear that a similar attack may be made upon us.

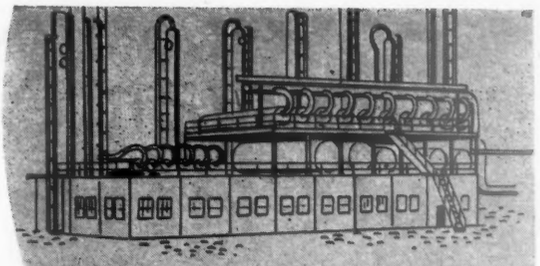
"These companies are charged with having gone out with their own money to find oil in previously unproductive areas of the world, of developing this production and of winning and keeping for the U. S. a preeminent place in the petroleum world trade. It is difficult to see how this accomplishment interfered with small business. Certainly no small company has the resources necessary to undertake the development of oil fields in the Middle East," Craig declared.

Frank M. Porter, president of the American Petroleum Institute, has also spoken out against the cartel charges. He declared that the API "does not engage nor has it ever engaged in activities that could be considered even remotely of a cartel nature."

In answer to a statement in a Federal Trade Commission report which associated the Institute with the alleged oil cartel, Porter declared:

"The American Petroleum Institute does not engage nor has it ever engaged in activities that could be considered even remotely of a cartel nature. The charges made in the Federal Trade Commission's report arise from a complete misunderstanding and misinterpretation of the Institute's efforts in the field of crude oil conservation when, in 1929, at the insistence of a governmental agency, the Federal Oil Conservation Board, it made through committees recommendations to that Board looking to the conservation and prevention of waste of this irreplaceable natural resource."

Proof of performance:



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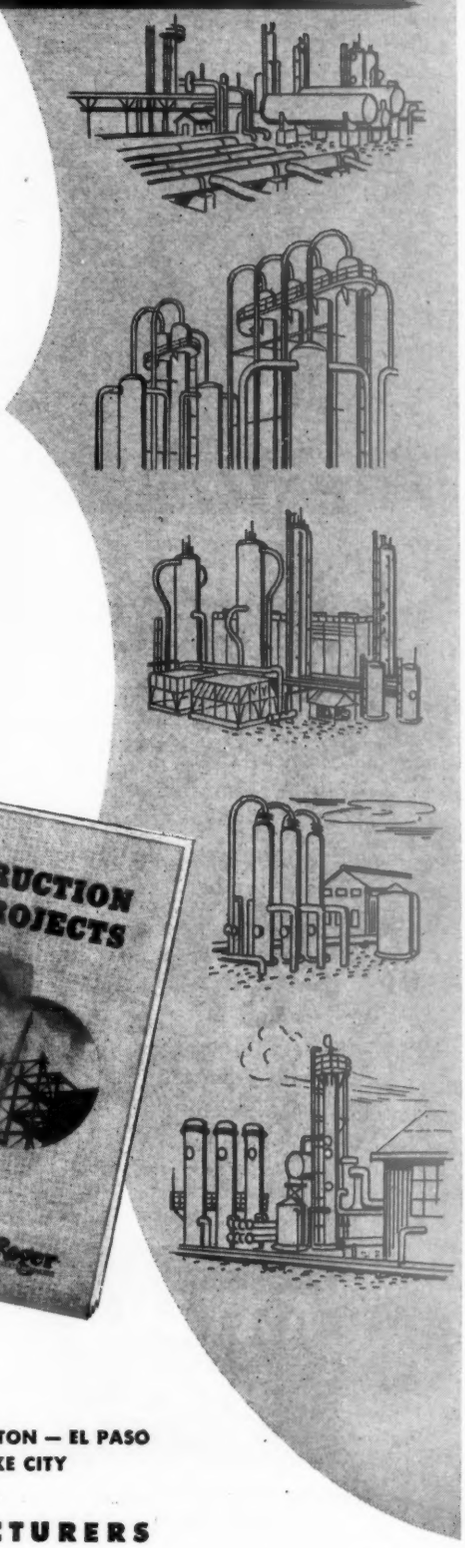

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Familiar Scenes
IN OIL FIELD SERVICE

This gas gathering line is just one of the ways in which Naylor Pipe serves the gas and oil industry. Distinctive Naylor Pipe offers structural and performance advantages for gas and oil lines, salt water disposal, sludge lines, vacuum lines, syphon pipe, tank gauge and swing pipe. Diameters from 4" to 30". Write for Bulletin No. 507.

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News

Crude Production Rises In Week Ended September 13

An increase in crude oil production and in crude runs was reported by the Bureau of Mines, United States Department of the Interior for the week ended September 13. Daily average output of crude was 6,461,000 bbl or 19,000 bbl above the comparable total of the preceding week, the API reported. Daily average crude runs to stills of 7,059,000 bbl were 38,000 bbl above the revised figure of 7,021,000 bbl for the preceding week and 515,000 bbl above the week ended September 15, 1951. For the four-week period ending September, crude oil production averaged 6,368,000 bbl daily.

Stocks of domestic and foreign crude petroleum at the close of the week ended September 13 totaled 264,350,000 bbl. Compared with the total of 265,665,000 bbl for the preceding week, this represents a decrease of 1,315,000 bbl comprising a decrease of 941,000 bbl in stocks of domestic crude and a decrease of 374,000 bbl in stocks of foreign crude.

Reservoir Conditions Is Subject of B of M Report

Field tests made by the Bureau of Mines' Petroleum and Natural Gas Branch have proved that reservoir conditions are favorable for the injection of gas or water to maintain pressure and increase ultimate recovery in Scurry, Borden, and Kent counties, Texas.

This was made known in a report prepared by R. A. Cattell, chief of the petroleum and natural gas branch and others. Object of the study was to learn more about reservoir conditions in the fields where production is declining, apply special techniques in solving field problems, and explore characteristics and behavior of rocks and the fluids they contain. Secondary recovery field studies reported were carried on in Oklahoma, Texas, West Virginia, and California.

Free copy of the Information Circular 7643, "Petroleum and Natural-Gas Research Programs, Bureau of Mines, Fiscal Year 1951" can be obtained from Bureau of Mines, 4800 Forbes Street, Pittsburgh, Pennsylvania.

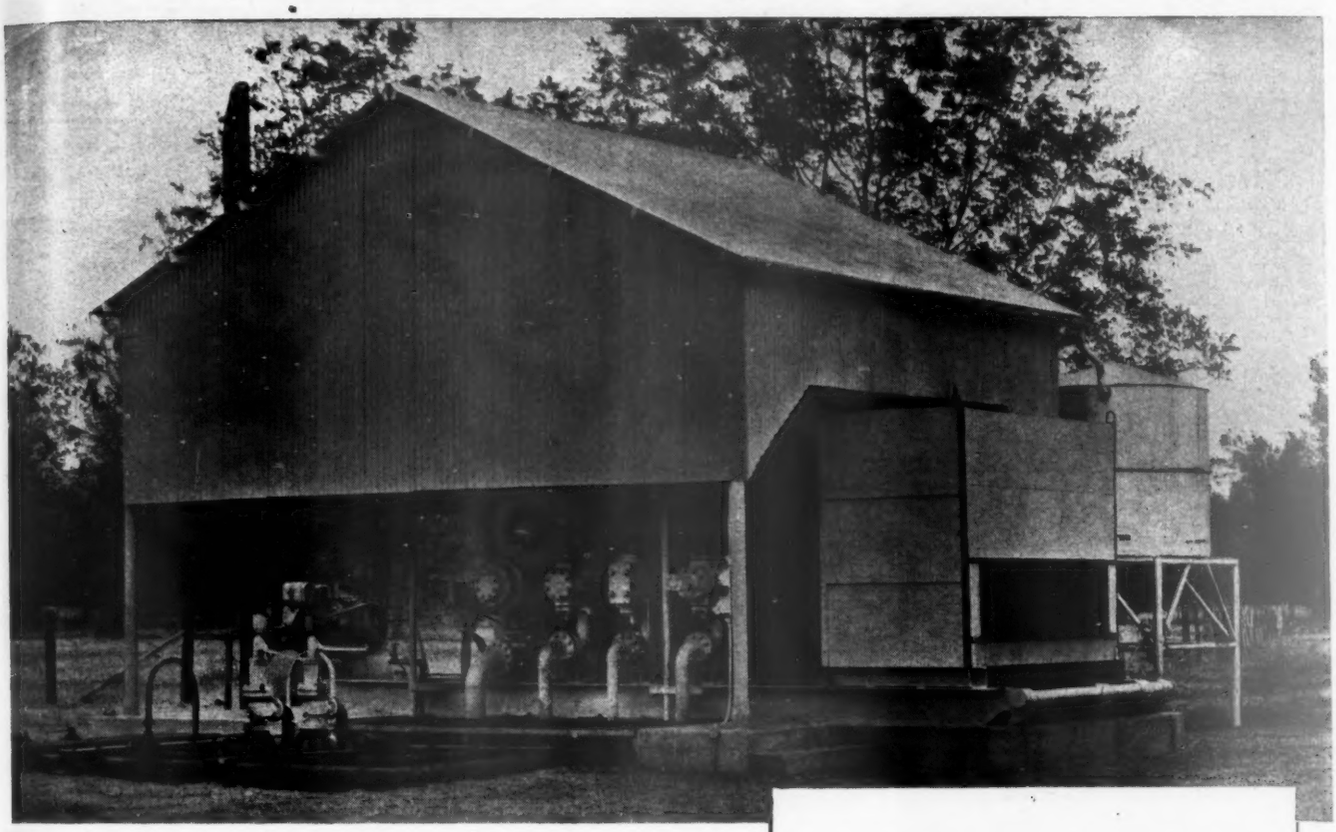
The report also devotes considerable space to a discussion of the therodynamics of petroleum hydrocarbons.

Research Group to Meet

The first regular meeting of the Operations Research Society, which was formed by a group of leading scientists in May, 1952, will be held at the National Bureau of Standards in Washington, D. C., on November 17 and 18.

The Society, whose purpose is to promote the application of scientific methods to business and military problems, will hear and discuss papers involving industrial applications of Operations Research; waiting lines; inventories and the use of probability techniques in industry; and the newly-developed Monte Carlo method for handling problems which cannot be solved with ordinary equations.

field gas pressures falling?



Clark has the answer...

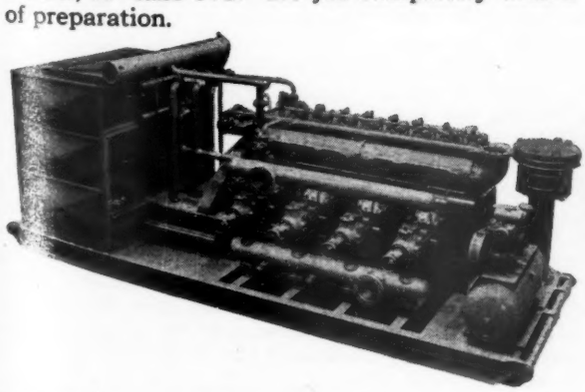
Are you confronted with the problem of field gas pressures falling faster than anticipated? Do you have inadequate compressor horsepower in existing field gathering stations to cope with these conditions?

The obvious answer, of course, is to add more horsepower. Where and how to install it with the least possible disruption of existing plant facilities is an additional problem. The most economical location, not only from the standpoint of reduced pipe size and consequently reduced cost, but also with overall horsepower requirements in mind, is at the point of highest suction pressure or at the well. The simplest, most practical field compressor suited to this use is the Clark Midget Angle.

Factory "packaged" into a complete semi-portable compressor station, it is all set to go to work the day it is received. It has the stamina and ruggedness — the Clark quality and dependability backed by over 600 field installations, to "take over" the job completely with a minimum of preparation.

"Midget Angles"

- **Perfect balance virtually eliminates foundation. A simple concrete slab is sufficient.**
- **Needs only a roof in most cases.**
- **Ready to tie in the day it arrives. It's "factory packaged".**
- **Because it's so rugged, very little attention is required. One man can handle a number of units.**
- **Does not interfere with present compressor station facilities.**
- **Easily trucked over lease roads and bridges without disassembly. It's small and compact.**



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Air-transportable tank being detached from chassis for loading.

Army Tests Fuel Tank for Ground and Air Supply

A newly designed mobile petroleum tank intended as an auxiliary source of bulk petroleum supply by land or air is undergoing field testing by the Army Quartermaster Corps, it was announced by the Department of the Army.

Two experimental models of the 800-gal fuel tank were constructed for the Quartermaster Corps by the Martin Parry Corporation of Toledo, Ohio. Drawn in tandem behind an Army truck, they were exhibited in Washington, D. C., before being taken to the Army Quartermaster Center at Fort Lee, Virginia, for a series of tests. The tanks will be towed at high speeds over rough roads and terrain, loaded and unloaded in cargo aircraft, and studied for general usefulness and serviceability.

The complete experimental units are 13½ ft long, 6½ ft high, and each weighs 4500 lb empty. The aluminum fuel tank alone weighs 1650 lb empty, and 6400 lb when filled with petroleum.

The tank is fastened to and removed from its chassis by use of a quick-clamping device. Twelve small wheels on each side of the tank facilitate its loading and unloading aboard an aircraft. The tanks from two or more units may be stacked upon each other for transport, however, the entire equipment, including chassis, may be transported by air.

Purpose of the mobile tank is to provide means for carrying more bulk petroleum supplies forward by Quartermaster Supply Companies, and also to give more efficient method of transporting bulk petroleum supplies by air, which now go in 55-gal drums.

Texas' October Oil Output Set at State's Highest Rate

Texas oil wells are producing at the highest rate in the history of the industry this month, with most of the state operating on a 23-production day rate. The Texas Railroad Commission has set the total allowables at 3,268,813 bbl per day, an increase of 4344 bbl per day more than that allowed last month.

East Texas fields, contrary to most sections of the state, were cut back a day and given 18 days to produce in, cutting total output by some 21,500 bbl daily for the fields. The cut was a result of testimony showing reservoir pressure in the East Texas fields had dropped three pounds in August.

Bryan W. Payne, president of Texas Independent Producers and Royalty Owners Association, speaking before the Commission declared that any reduction in allowables might give importing companies "justification for stepping up imports which already are at peril points." He warned that with the new tariff reductions "the equivalent of a 10 per cent increase in price on imported oil" might give the importing companies an excuse to unload more foreign oil on the market in the name of free trade. He said the Texas Commission deserved praise for "letting Texas production fill firm market demand for more crude, rather than acquiescing to the importing companies demand that it be filled from storage."

Tubular Goods Authorizations Slashed in Third Quarter

The Petroleum Administration for Defense has authorized purchases of 31,000 tons of conversion oil country tubular goods for the fourth quarter, considerably under the 434,665 tons requested by oil and gas operators. Administrator J. Ed Warren announced the cut, and added that though the PAD regretted having to make the "drastic slash," mill production on that large a scale is not available now. He said there would be no point in issuing authorizations for the purchase of pipe that does not exist.

In the meantime, PAD is trying to work out a substantial boost of foreign output of oil-country tubular goods. Production of pipe by steel mills in 1951 in free Europe and the United Kingdom has been estimated by PAD at about 170,000 tons, with output to reach about 250,000 tons this year. PAD said it is working through Mutual Security Agency to make it possible for American oil companies operating abroad to get a higher proportion of their needs from foreign mills.

NACE Conference Set

The western region of the National Association of Corrosion Engineers has scheduled its second annual corrosion conference for November 20-21 at the Biltmore Hotel in Los Angeles.

Topics devoted to the general theme —applied research—will be conducted during the two-day session by nationally recognized corrosion engineers. Included in the program are a group luncheon on the 20th and dinner on the 21st, which will provide the opportunity to discuss mutual problems with both suppliers and fellow workers.

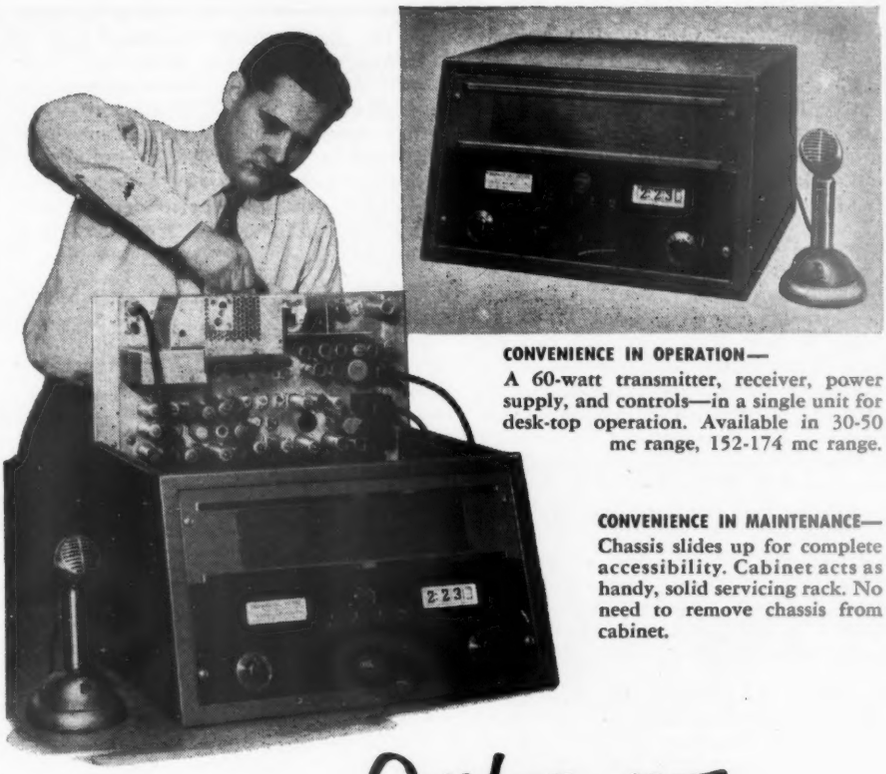
Announcements will be sent to all western region members. Housing is on an individual basis and advance registration may be made through W. M. Schilling—conference chairman and regional chairman.

New OIIC Film Available

The story of a split-second decision that becomes the turning point in a young man's life is told in the 1952 motion picture produced by the Oil Industry Information Committee of the American Petroleum Institute. The setting is a suburban service station. "Crossroads, U.S.A.," is the latest in a series of motion pictures produced annually by OIIC. It will be used extensively during the industry's observance of Oil Progress Week, October 12-18.

Prints of "Crossroads, U.S.A.," may be obtained through the Committee's national office at 50 West 50th Street, New York 20, as follows: 16-millimeter, $42.50, plus shipping costs; 35-millimeter, $100, plus shipping costs.

OIL OPERATORS AND PRODUCERS: Interested in wildcat leases and in actual or contemplated drilling operations. Will exchange cash or casing for partnership in oil-producing properties. Write Box 145 care of THE PETROLEUM ENGINEER, P. O. Box 1589, Dallas Texas.



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Just plug in transmission line and AC power and you are ready to operate. Lift-out chassis for servicing in cabinet. Metering plugs for easy checking.

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Local or remote operation
Choice of local or remote control base station in single, compact cabinet. Chassis also available in standard cabinet rack or weatherproof, pole-mounting box.

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DEATHS

William Clayton Witt, II, formerly in the engineering department of Atlantic Refining Company, Dallas, Texas, was killed in an automobile accident August 23, near Odessa, Texas. A graduate of Southern Methodist University and Tulane University, Witt was living in Midland at the time of his death.

Ward Payne Anderson, general manager of the Refining division, Eastern operations, California Texas Oil Company, Ltd., died suddenly August 12 at his home in New York City. He had not been ill previously. Anderson was graduated from the University of California with a BS degree in 1925, and joined the research and development department of the Richmond, California, refinery of Standard Oil of California, one of the parent companies of California Texas Oil Company. He went to Bahrain, in the Persian Gulf in 1936 as superintendent of the refinery then being built there. He became general manager at Bahrain in 1942, and in 1946, was transferred to the New York offices of Caltex.

L. E. Sloan, district production superintendent for Stanolind Oil and Gas Company at Abilene, Texas, died in Abilene on August 19, after a brief illness. A veteran of 41 years in the oil business, Sloan was in charge of drilling and production operations for Stanolind in the North-Central and Panhandle areas of Texas.

During his long career, Sloan worked in the Burkburnett oil boom and in various operations in Oklahoma, Kansas, and Texas. He was employed by Mc-Man Oil and Gas Company when that company and several others were merged in 1931 to form Stanolind Oil and Gas Company. In 1935, he was promoted to district superintendent, serving at Midland, Fort Worth, Pampa, and Abilene.

William R. Ray, inventor, industrialist, and engineer, died at his Los Angeles, California, home in August.

Chairman of the board of directors of the General Controls Company of Glendale at the time of his death, Ray was responsible for the development of the horizontal rotary oil burner, the dual pump and reservoir, and many other improvements in the combustion, automatic controls, and heating fields.

A mechanical genius, Mr. Ray was credited with the invention of an oil burner which, for the first time, made it economically possible to use oil for heating and power purposes.

Harry F. Mitchell, treasurer of the Union Gas System, Inc., and a civic leader of Independence, Kansas, for many years, died unexpectedly at St. Luke's Hospital in Kansas City, September 1. Mitchell had entered the hospital the week before his death for surgery.

He had been an officer and director of the Union Gas System for more than 30 years, and was one of the oldest employees in point of service. He was also an officer of Midland Industries, Inc., and Gibraltar Finance Corporation.

Harold J. Buck, general sales manager of the American Liberty Oil Company, died September 15. Buck joined the company in Dallas, Texas, in 1940. Prior to joining American Liberty, he had been sales manager of Allied Materials in Oklahoma City. He was a graduate of Colorado State University with a degree in civil engineering. He was ex-chairman of the board of Asphalt Institute and member of the Society of American Military Engineers.

H. Roddie Cook, chief clerk in the production department of Carter Oil Company died September 15. An employee of Carter Oil for 36 years, Cook died of a heart attack in his office in Tulsa, Oklahoma.

George B. Talbot, founder of Talbot Oil Company, American Drilling Company, and Midway Tool Company, died in Saginaw, Michigan, September 12. Talbot was president of the Oil and Gas Association of Michigan in 1948.

Larry Ziess, engineer for Magnolia Petroleum Company at Falfurrias, Texas, was killed in a rig accident, September 14.

Emery A. Miller, retired drilling contractor died September 7 at his home in Bartlesville, Oklahoma. Miller, who was a native of Ohio, came to Bartlesville in 1913.

Doyce Adamson, 26-year-old architect for Continental Oil Company, Ponca City, Oklahoma, died September 4. He was a polio patient in the Stillwater, Oklahoma, hospital.

Don Franz Tilden, a retired oil producer, died in Claremore, Oklahoma, September 5. A native of Renrock, Ohio, he began his career in Louisiana and went to Oklahoma in the early 1900's.

Dr. M. R. Schmidt, general superintendent of the Whiting, Indiana, refinery for Standard Oil Company (Indiana), died recently.

Kenneth W. Borror, Mount Pleasant, Michigan, landman for Sun Oil Company for the last 15 years, died in a Columbus, Ohio, hospital recently. He resided in Mount Pleasant, Michigan.

L. E. Sloan, district production superintendent for Stanolind Oil and Gas Company died in Abilene, Texas, recently. Sloan had been in the oil business for 41 years, and had worked in the Burkburnett oil boom and in oil areas in Texas, Kansas, and Oklahoma.

E. L. Chapman, owner of Southland Geophysical Service, died August 19 in Jackson, Mississippi. Chapman was an oil operator in Arkansas, Louisiana, and Texas.

Virgil Gorby, driller for Turner Drilling Corporation, was killed in a drilling accident in Shelby field, Oceana County, Michigan, recently.

Speed Your Loading Racks with EVERLASTING VALVES

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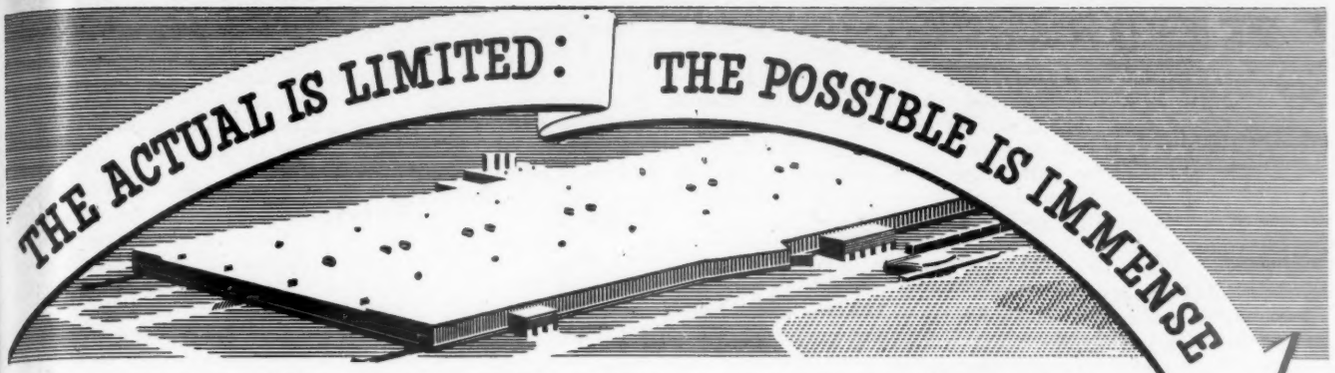

NEW LINCOLN PLANT CREATED BY INCENTIVE-INSPIRED CO-ACTION IN DEVELOPING POSSIBILITIES IN PRODUCT

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LINCOLN SPEED AND DEPENDABILITY KEEP WELDING COSTS DOWN ON THE TEXAS-ILLINOIS LINE

THE rough terrain of the 480-mile stretch of the Texas-Illinois line constructed by the H. C. Price Company required using the stove-pipe method exclusively. After pipe joints were lined up with internal clamps, three-man teams laid initial beads. The joint was then welded using standard procedures, 30° bevels and three passes. Welds were made with Lincoln "Fleetweld 5" and "Shield-Arc 85" electrodes, pressure tested at 750 psi and found free of porosity.

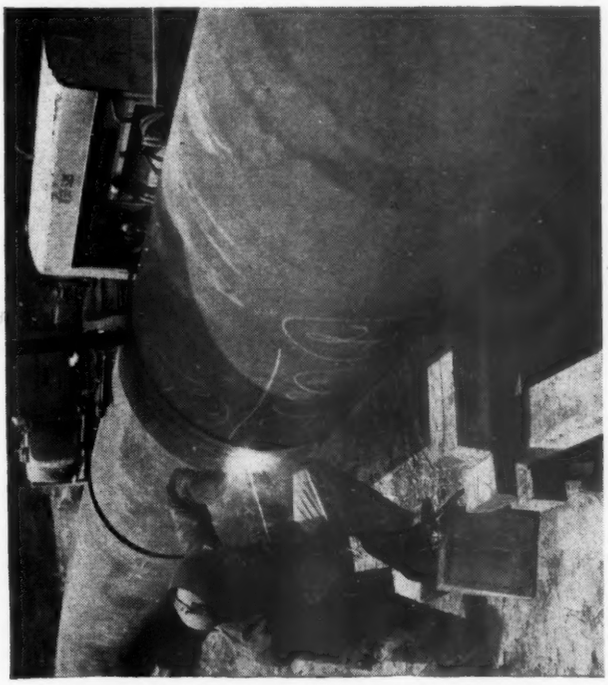

Fig. 3. Welder *produces final pass with Lincoln "Fleetweld 5" electrode for high-pressure, quality joint on 30-inch Texas-Illinois Line.*

SPEEDS PIPELINE CONSTRUCTION

Fig. 1. Tie-in Weld *on 30-inch line is made with Lincoln "Fleetweld 5" electrode along the Texas-Illinois right-of-way. Line-up clamp positions pipe for welding.*

MORE FOOTAGE PER DAY

Fig. 2. Three-man team *instead of the usual two applies initial weld bead. Lincoln "Shield-Arc" engine driven welders supply correct type of arc and right arc intensity for fast, quality welding.*

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THE WORLD'S LARGEST MANUFACTURER OF ARC WELDING EQUIPMENT

PERSONALS

Cecil L. Burrill has been named vice president and director of Creole Petroleum Corporation. He is presently in charge of Creole's New York office. A graduate and former member of the faculty of the Harvard Business School, Burrill joined Creole Petroleum Corporation in 1949. Prior to that time, he was head of the budget department and petroleum economist of Standard Oil Company (New Jersey).

Burrill returned to Creole recently after serving 18 months as director of the program division of Petroleum Administration for Defense.

Arthur W. Scott, president of Wolf's Head Oil Refining Company, Inc., Oil City, Pennsylvania, has been elected president of the National Petroleum Association. He succeeded **Earle M. Craig,** chairman of the board of Freedom-Valvoline Oil Company, Freedom, Pennsylvania.

Fred G. Bannerot, Jr., president of Elk Refining Company, Charleston, W. Va., was elected first vice president, and **Paul R. Beck,** president of Pennsylvania Refining Company, Butler, Pennsylvania, was elected second vice president.

E. M. Lyons, of Philadelphia, **G. B. Hunter,** of Oil City, Pennsylvania, and **Margaret Miller,** of Washington, were re-elected recording secretary, treasurer and assistant treasurer, respectively.

Robert B. Anderson of Vernon, Texas, general manager of the oil and ranching interests of the W. T. Waggoner estate, was elected a director of the Southwestern Bell Telephone Company, it was announced recently.

A native of Burleson, Anderson is a graduate of the University of Texas Law School. At the age of 37 he became president of the Texas Mid-Continent Oil and Gas Association, retiring from that position last October. He is director of numerous associations including the General Mid-Continent Oil and Gas Association, and the American Petroleum Institute.

W. T. Lynde has been appointed senior district representative for the Gulf-Southwest district of the Oil Industry Information Committee, it was announced by E. W. Esmay, acting director of the Department of Information, American Petroleum Institute. He succeeds **Don Agnew,** who resigned August 15.

Headquarters for the district are in Dallas, with sub-offices in New Orleans and Jackson, Mississippi. The district covers New Mexico, Texas, Louisiana, Mississippi, Alabama, and Arkansas.

Lynde joined the OIIC in Dallas in 1950, and has been working on the industry's public relations program especially in the states of Texas and New Mexico. After being graduated from the University of Missouri School of Journalism in 1940, he edited a county newspaper for a time before joining the Associated Press.

M. E. Hankins has been named divisional purchasing agent of The Texas Company, New York, to succeed **F. G. Shlemmer,** resigned. Hankins was formerly divisional purchasing agent, Chicago, Illinois. **E. C. Borg,** divisional purchasing agent, Los Angeles, California, has been transferred to Chicago to succeed Hankins, and **Philip Hauck** has been reappointed divisional purchasing agent, Los Angeles.

Allan W. Lundstrum, former vice president and general manager of Ohio Fuel Gas Company has been elected president, succeeding the late William N. Grinstead. Lundstrum is succeeded by **Everett D. Bivens,** formerly treasurer of Ohio Fuel and since 1951 vice president and general manager of United Fuel Gas Company, West Virginia and its six subsidiaries. Lundstrum was formerly director of research for United Gas Pipe Line at Shreveport.

William L. Batt, minister in charge of the Economic Cooperation Administration mission to the United Kingdom and president of SKF Industries, Inc., has been awarded the Howard Coonley Medal for long and distinguished service in the standardization movement. Announcement was made by the American Standards Association, which presents the award annually. Presentation will be made on November 25, at the 34th annual meeting of the Association in the Waldorf-Astoria, New York.

Eugene Holman, president of Standard Oil Company (New Jersey) has been awarded the State Fair of Texas' "Texan of Distinction" award. He was given the award at the annual State Fair banquet October 7, and is the first person to receive the award.

E. J. Valencia and **Lloyd L. Allen** were elected to the board of directors of Canadian Bishop Oil, Ltd. Valencia is treasurer of Bishop Oil Company and Allen is a member of the planning committee of the same firm.

William Wallace Mein, Jr., Charles W. Fay, and **Louis J. Brunel** have been named to the board of directors of Canadian Bishop Oil, Ltd. All three are members of the company's executive committee.

Mein was named president of the firm, which is the Canadian operating subsidiary of Bishop Oil Company. Other officers include Brunel as vice president, **E. J. Valencia** as treasurer and assistant secretary, and **Gardner W. Mein** as secretary.

Stuart Mossom has been transferred to Dallas, Texas, from Houston where he is assistant manager of the natural gas department for Magnolia Petroleum Company. In addition to his new duties, he will continue as coordinator of offshore operations for the company's exploration division.

Howard W. Page has announced his resignation as director of Esso Petroleum Company, Ltd., London, to assume additional duties for Standard Oil Company (New Jersey) in regard to European problems. Formerly executive assistant to the president of Jersey Standard, Page will continue as shareholders' representative for the firm in the United Kingdom.

Charles A. McWilliams of the bunker oil department, Socony-Vacuum Oil Company, Inc., has been transferred to London where he will be associated with the Socony Bunker Oil Company, Ltd.

K. H. Shaffer

C. W. Gibbs

Kenneth H. Shaffer has been appointed a vice president and director of The California Company, subsidiary of Standard Oil Company of California.

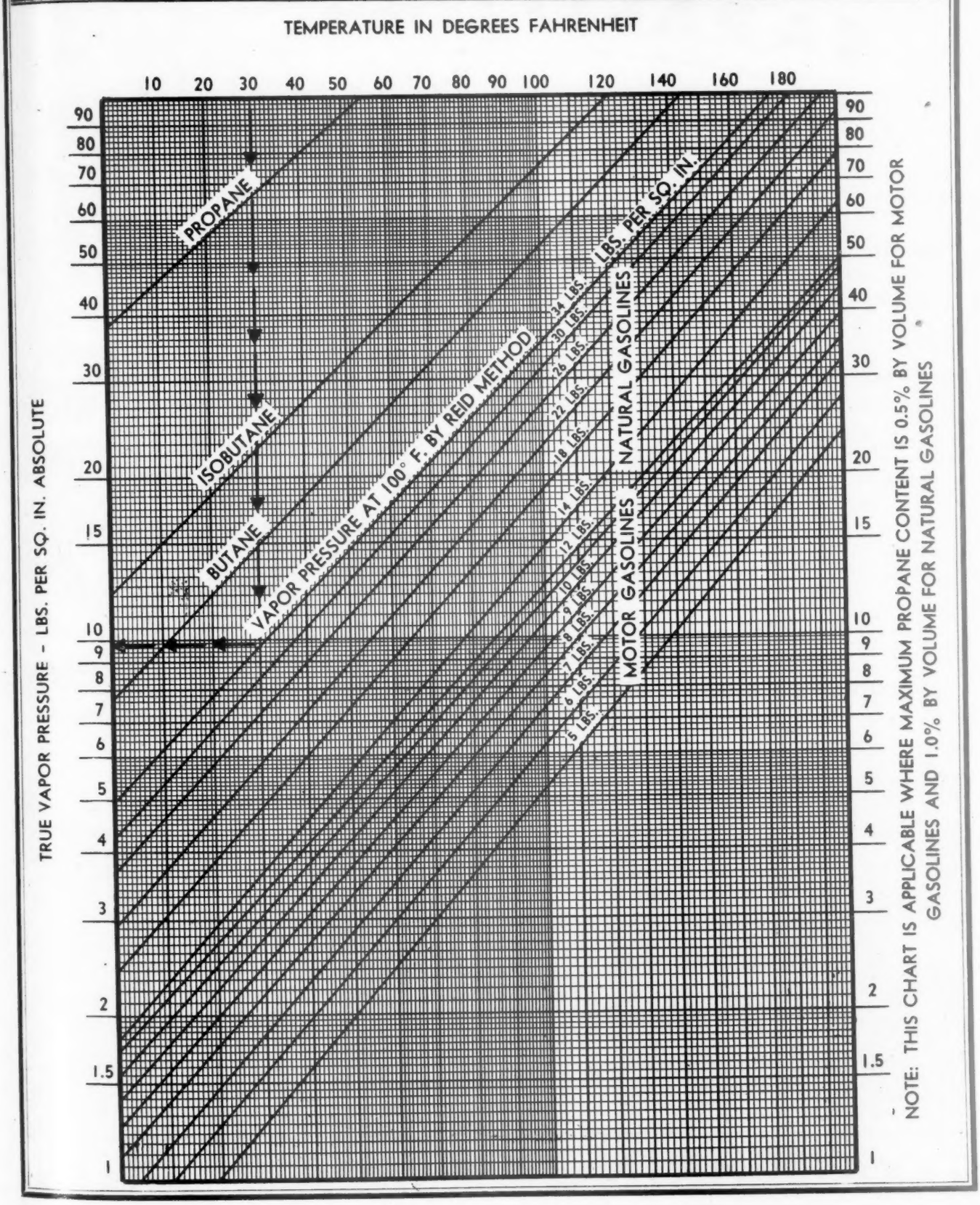
Succeeding Shaffer as assistant general manager of Standard's producing department will be **C. W. Gibbs,** since 1950 manager of the department's Northern (California) district. **W. A. Eardley,** previously chief petroleum engineer, will take over Gibbs' former post in Taft, California.

Shaffer is a graduate of the University of California. He joined Standard in 1929 and has had a diversity of experience with the company's producing, industrial relations, and personnel departments and with department on organization.

Gibbs is a Stanford University graduate. In 1922, he joined Pacific Oil Company, a firm which was acquired by Standard Oil of California.

Eardley was also graduated from Stanford. He joined Standard and has held a succession of increasingly important assignments as a petroleum engineer in the organization.

VAPOR PRESSURES VERSUS TEMPERATURES FOR MOTOR AND NATURAL GASOLINES


TEMPERATURE IN DEGREES FAHRENHEIT
10 20 30 40 50 60 70 80 90 100 120 140 160 180
TRUE VAPOR PRESSURE - LBS. PER SQ. IN. ABSOLUTE
90 80 70 60 50 40 30 20 15 10 9 8 7 6 5 4 3 2 1.5 1
PROPANE
ISOBUTANE
BUTANE
VAPOR PRESSURE AT 100° F. BY REID METHOD
LBS. PER SQ. IN.
34 LBS.
30 LBS.
26 LBS.
22 LBS.
18 LBS.
14 LBS.
12 LBS.
10 LBS.
9 LBS.
8 LBS.
7 LBS.
6 LBS.
5 LBS.
NATURAL GASOLINES
MOTOR GASOLINES
NOTE: THIS CHART IS APPLICABLE WHERE MAXIMUM PROPANE CONTENT IS 0.5% BY VOLUME FOR MOTOR GASOLINES AND 1.0% BY VOLUME FOR NATURAL GASOLINES

Extra WORK CAPACITY

WITH KOEHRING

25-TON 304 CRANE

Reserve strength and operating stability of Koehring 304 Crane gives 13.9-ton lift and boom lengths up to 75 feet on crawler mounting . . . 25-ton lift capacity and maximum reach up to 110 feet (including jib) on rubber-tired truck or cruiser mounting.

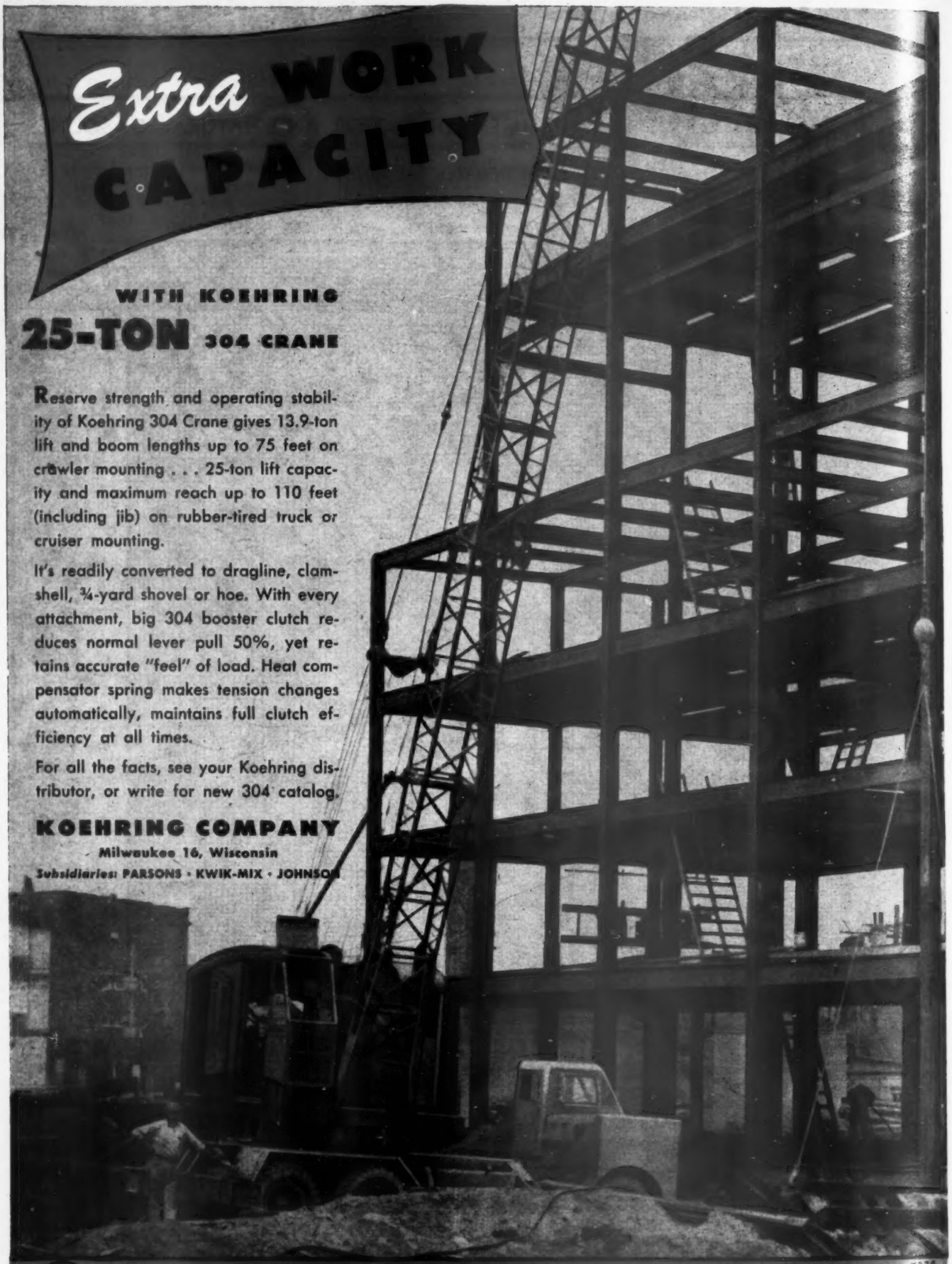
It's readily converted to dragline, clamshell, ¾-yard shovel or hoe. With every attachment, big 304 booster clutch reduces normal lever pull 50%, yet retains accurate "feel" of load. Heat compensator spring makes tension changes automatically, maintains full clutch efficiency at all times.

For all the facts, see your Koehring distributor, or write for new 304 catalog.

KOEHRING COMPANY

Milwaukee 16, Wisconsin

Subsidiaries: PARSONS • KWIK-MIX • JOHNSON



KOEHRING HEAVY DUTY

KOEHRING *heavy-duty* CRANES

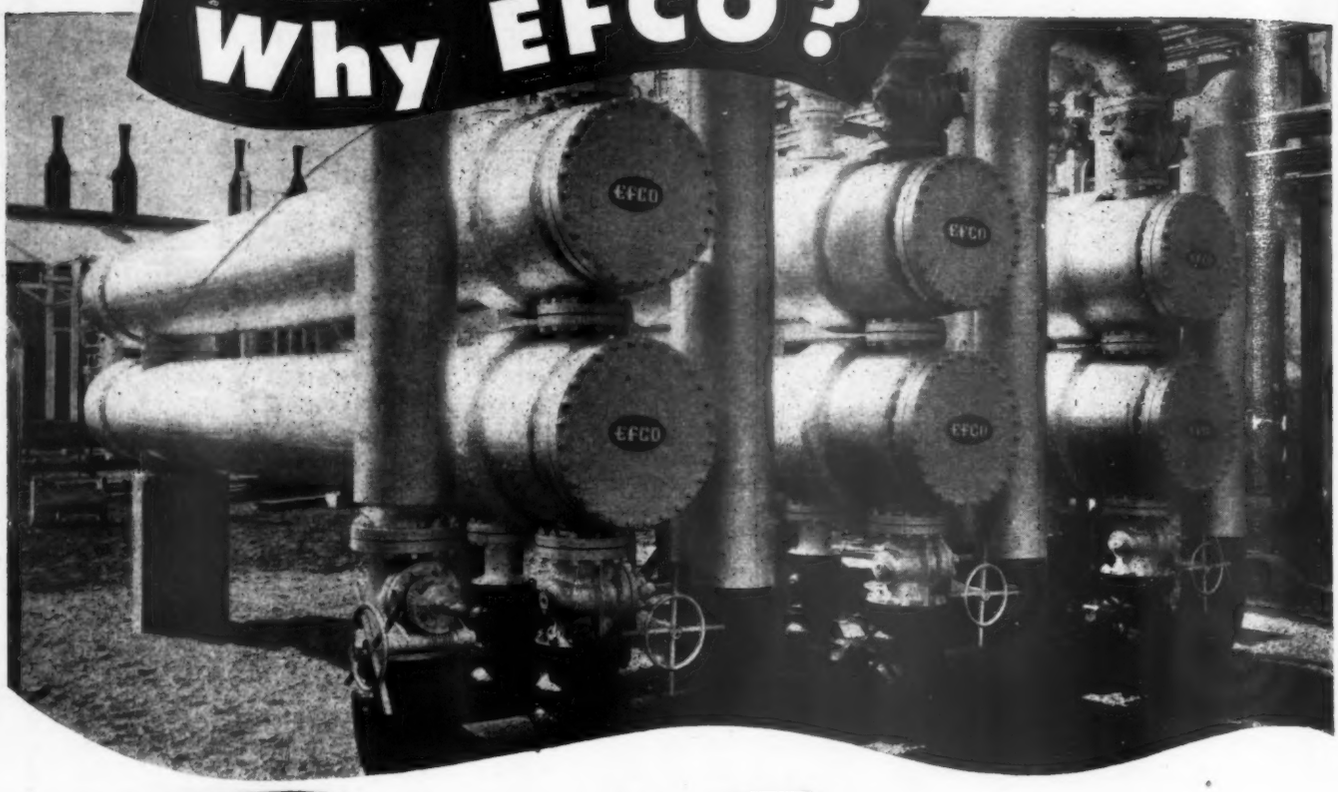
K276

7¾ to 79½ TONS lift capacities . . . EXCAVATORS ½ to 2½ yards

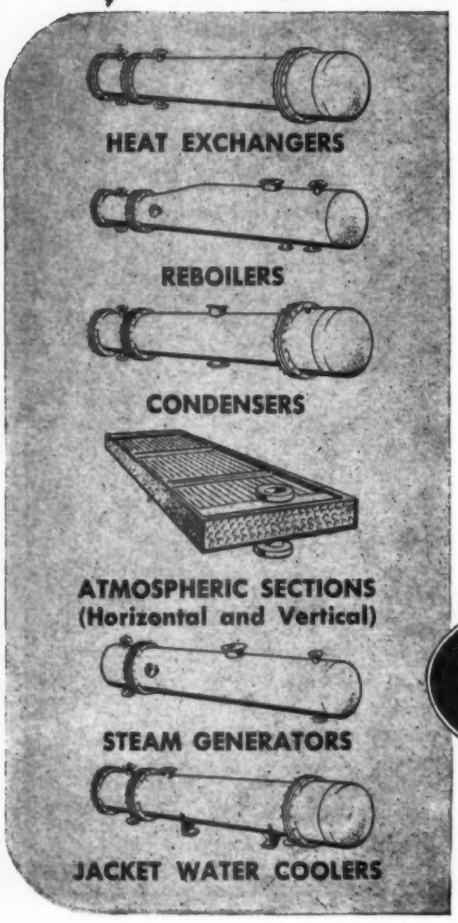
SPECIFIC GRAVITY OF SULPHURIC ACID SOLUTIONS AT VARIOUS TEMPERATURES

Weight percent of H_2SO_4	Temperature of solution										
	0° C 32° F	10° C 50° F	15° C 59° F	20° C 68° F	25° C 77° F	30° C 86° F	40° C 104° F	50° C 122° F	60° C 140° F	80° C 176° F	100 °C 212° F
51	1.4209	1.4128	1.4088	1.4049	1.4009	1.3970	1.3893	1.3816	1.3740	1.3590	1.3444
52	1.4310	1.4228	1.4188	1.4148	1.4109	1.4069	1.3991	1.3914	1.3837	1,3687	1.3540
53	1.4412	1.4329	1.4289	1.4248	1.4209	1.4169	1.4091	1.4013	1.3936	1.3785	1.3637
54	1.4515	1.4431	1.4391	1.4350	1.4310	1.4270	1.4191	1.4113	1.4036	1.3884	1.3735
55	1.4619	1.4535	1.4494	1.4453	1.4412	1.4372	1.4293	1.4214	1.4137	1.3984	1.3834
56	1.4724	1.4640	1.4598	1.4557	1.4516	1.4475	1.4396	1.4317	1.4239	1.4085	1.3934
57	1.4830	1.4746	1.4703	1.4662	1.4621	1.4580	1.4500	1.4420	1.4342	1.4187	1.4035
58	1.4937	1.4852	1.4809	1.4768	1.4726	1.4685	1.4604	1.4524	1.4446	1.4290	1.4137
59	1.5045	1.4959	1.4916	1.4875	1.4832	1.4791	1.4709	1.4629	1.4551	1.4393	1.4240
60	1.5154	1.5067	1.5024	1.4983	1.4940	1.4898	1.4816	1.4735	1.4656	1.4497	1.4344
61	1.5264	1.5177	1.5133	1.5091	1.5048	1.5006	1.4923	1.4842	.4762	1.4602	1.4449
62	1.5375	1.5287	1.5243	1.5200	1.5157	1.5115	1.5031	1.4950	1.4869	1.4708	1.4554
63	1.5487	1.5398	1.5354	1.5310	1.5267	1.5225	1.5140	1.5058	1.4977	1.4815	1.4660
64	1.5600	1.5510	1.5465	1.5421	1.5378	1.5335	1.5250	1.5167	1.5086	1.4923	1.4766
65	1.5714	1.5623	1.5578	1.5533	1.5490	1.5446	1.5361	1.5277	1.5195	1.5031	1.4873
66	1.5828	1.5736	1.5691	1.5646	1.5602	1.5558	1.5472	1.5388	1.5305	1.5140	1.4981
67	1.5943	1.5850	1.5805	1.5760	1.5715	1.5671	1.5584	1.5499	1.5416	1.5249	1.5089
68	1.6059	1.5965	1.5920	1.5874	1.5829	1 5785	1.5697	1.5611	1.5528	1.5359	1.5198
69	1.6176	1.6081	1.6035	1.5989	1.5944	1.5899	1.5811	1.5724	1.5640	1.5470	1.5307
70	1.6293	1.6198	1.6151	1.6105	1.6059	1.6014	1.5925	1.5838	1.5753	1.5582	1.5417
71	1.6411	1.6315	1.6268	1.6221	1.6175	1.6130	1.6040	1.5952	1.5867	1.5694	1.5527
72	1.6529	1.6433	1.6385	1.6338	1.6292	1.6246	1.6155	1.6067	1.5981	1.5806	1.5637
73	1.6648	1.6551	1.6503	1.6456	1.6409	1.6363	1.6271	1.6182	1.6095	1.5919	1.5747
74	1.6768	1.6670	1.6622	1.6574	1.6526	1.6480	1.6387	1.6297	1.6209	1.6031	1.5857
75	1.6888	1.6789	1.6740	1.6692	1.6644	1.6597	1.6503	1.6412	1.6322	1.6142	1.5966
76	1.7008	1.6908	1.6858	1.6810	1.6761	1.6713	1.6619	1.6526	1.6435	1.6252	1.6074
77	1.7128	1.7026	1.6976	1.6927	1.6878	1.6829	1.6734	1.6640	1.6547	1.6361	1.6181
78	1.7247	1.7144	1.7093	1.7043	1.6994	1.6944	1.6847	1.6751	1.6657	1.6469	1.6286
79	1.7365	1.7261	1.7209	1.7158	1.7108	1.7058	1.6959	1.6862	1.6766	1.6575	1.6390
80	1.7482	1.7376	1.7323	1.7272	1.7221	1.7170	1.7069	1.6971	1.6873	1.6680	1.6493
81	1.7597	1.7489	1.7435	1.7383	1.7331	1.7279	1.7177	1.7077	1.6978	1.6782	1.6594
82	1.7709	1.7599	1.7544	1.7491	1.7437	1.7385	1.7281	1.7180	1.7080	1.6882	1.6692
83	1.7815	1.7704	1.7649	1.7594	1.7540	1.7487	1.7382	1.7279	1.7179	1.6979	1.6787
84	1.7916	1.7804	1.7748	1.7693	1.7639	1.7585	1.7479	1.7375	1.7274	1.7072	1.6878
85	1.8009	1.7897	1.7841	1.7786	1.7732	1.7678	1.7571	1.7466	1.7364	1.7161	1.6966
86	1.8095	1.7983	1.7927	1.7872	1.7818	1.7763	1.7657	1.7552	1.7449	1.7245	1.7050
87	1.8173	1.8061	1.8006	1.7951	1.7897	1.7842	1.7736	1.7632	1.7529	1.7324	1.7129
88	1.8243	1.8132	1.8077	1.8022	1.7968	1.7914	1.7809	1.7705	1.7602	1.7397	1.7202
89	1.8306	1.8195	1.8141	1.8087	1.8033	1.7979	1.7874	1.7770	1.7669	1.7464	1.7269
90	1.8361	1.8252	1.8198	1.8144	1.8091	1.8038	1.7933	1.7829	1.7729	1.7525	1.7331
91	1.8410	1.8302	1.8248	1.8195	1.8142	1.8090	1.7986	1.7883	1.7783	1.7581	1.7388
92	1.8453	1.8346	1.8293	1.8240	1.8188	1.8136	1.8033	1.7932	1.7832	1.7633	1.7439
93	1.8490	1.8384	1.8331	1.8279	1.8227	1.8176	1.8074	1.7974	1.7876	1.7681	1.7485
94	1.8520	1.8415	1.8363	1.8312	1.8260	1.8210	1.8109	1.8011	1.7914		
95	1.8544	1.8439	1.8388	1.8337	1.8286	1.8236	1.8137	1.8040	1.7944		
96	1.8560	1.8457	1.8406	1.8355	1.8305	1.8255	1.8157	1.8060	1.7965		
97	1.8569	1.8466	1.8414	1.8364	1.8314	1.8264	1.8166	1.8071	1.7977		
98	1.8567	1.8463	1.8411	1.8361	1.8310	1.8261	1.8163	1.8068	1.7976		
99	1.8551	1.8445	1.8393	1.8342	1.8292	1.8242	1.8145	1.8050	1.7958		
100	1.8517	1.8409	1.8357	1.8305	1.8255	1.8205	1.8107	1.8013	1.7922		

Why EFCO?



Performance is the answer!

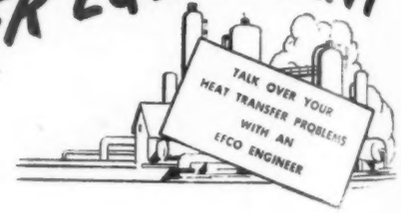


With the installation of EFCO heat transfer units in your plant, you will be sure of getting *guaranteed performance* with the extra advantages of low maintenance cost, high operating efficiency, long life and freedom from leaks.

Talk over your heat transfer problems with an EFCO engineer. He will tell you about EFCO installations that have successfully solved problems similar to yours and explain how EFCO equipment will give you the performance you want.

ENGINEERS & FABRICATORS, INC.
P. O. Box 7395 Houston 8, Texas

EFCO HEAT TRANSFER EQUIPMENT



Note: This table replaces that on page E-21 of the August 1952 issue.

VISCOSITY CONVERSION FACTORS

Saybolt universal seconds	Engler degrees	Absolute viscosity, centipoises,[1] also relative viscosity	Kinematic viscosity, poises per g. per cc, n/d	Redwood No. 1 seconds	Saybolt Furol seconds	Redwood admiralty seconds
32	1.08	1.41	0.0141			30
34	1.14	2.19	.0219			31
36	1.19	2.92	.0292			33
38	1.25	3.63	.0363			34
40	1.31	4.30	.0430			36
42	1.37	4.95	.0495			38
44	1.43	5.59	.0559			39
46	1.48	6.21	.0621			41
48	1.53	6.81	.0681			43
50	1.58	7.40	.0740			44
55	1.73	8.83	.0883			48
60	1.88	10.20	.1020			53
65	2.03	11.53	.1153			57
70	2.17	12.83	.1283			61
75	2.31	14.10	.1410			65
80	2.46	15.35	.1535			69
85	2.59	16.58	.1658			73
90	2.74	17.80	.1780			77
95	2.88	19.00	.1900			81
100	3.02	20.20	.2020	10	15	86
110	3.31	22.56	.2256	11	16	94
120	3.60	24.90	.2490	12	17	102
130	3.69	27.21	.2721	13	18	111
140	4.19	29.51	.2951	13	18	119
160	4.77	34.07	.3407	15	20	136
180	5.35	38.60	.3860	17	22	153
200	5.92	43.10	.4310	19	23	170
225	6.64	48.70	.4870	21	26	191
250	7.35	54.28	.5428	23	28	212
300	8.79	65.40	.6540	28	32	254
350	10.25	76.49	.7649	32	37	296
400	11.68	87.55	.8755	37	42	338
450	13 00	98.60	.9860	42	47	380
500	14 00	109.6	1.096	46	52	422
550	16.00	120.7	1.207	50	56	465
600	17.00	131.7	1.317	55	61	507
650	19.00	142.7	1.427	60	66	549
700	20.00	153.7	1.537	64	71	591
800	23.00	175.8	1.758	74	81	676
900	26.00	197.8	1.978	83	91	760
1000	29.00	219.8	2.198	92	101	845
1500	43.00	329.9	3.299	138	150	1267
2000	58.00	439 9	4.399	184	200	1690
2500	72 00	549.9	5.499	230	250	2112
3000	87 00	659.9	6.599	276	300	2535
3500	101 00	769 9	7 699	322	350	2957

[1]Values in this column must be multiplied by the specific gravity of the fluid at the temperature of the measurement to complete the conversion

How to Work at FULL TILT and lose less than ever!

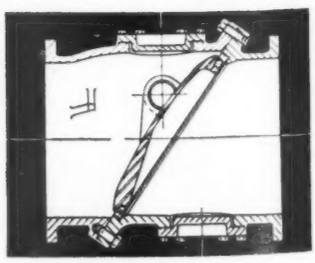
INSTALL

CHAPMAN

Tilting-Disc Check Valves

Take another look at the diagram below. That tilting disc actually *balances as it closes* . . . so that it cushions itself into a drop-tight seat . . . without any slamming under usual piping arrangements.

This means far lower head loss than with other types of check valves. It means, too, far lower rate of wear of moving parts . . . for the disc is the *only* moving part. In fact, it means more savings and less trouble than you ever knew you could get with *any* check valve. Write for Catalog No. 30, giving complete test results at some of the country's leading engineering laboratories.



Cross-section of the Chapman Tilting-Disc Check Valve. A feature of the design is that the disc seat lifts away from the body seat when opening, and drops into contact when closing, with no sliding or wearing of the seats.

THE CHAPMAN VALVE MFG. CO.
INDIAN ORCHARD, MASSACHUSETTS

VOLUME OF GAS LOST IN BLOWDOWN OF LINE

(Gas volumes in table are in M cu. ft. per 1000 ft. of line)

Initial line pressure on shut-in section, lb. per sq. in., ga.	Nominal diameter of line, in.																	
	2	2½	3	3½	4	5	6	8	10	12	14	15	16	17	18	20	22	24
25	0.040	0.057	0.088	0.117	0.151	0.237	0.342	0.606	0.967	1.360	1.634	1.890	2.164	2.446	2.747	3.423	4.175	5.000
50	.080	.113	.175	.234	.302	.474	.685	1.213	1.934	2.722	3.269	3.781	4.330	4.894	5.495	6.849	8.353	10.00
75	.119	.170	.263	.352	.453	.711	1.027	1.819	2.901	4.082	4.903	5.670	6.494	7.340	8.242	10.27	12.53	15.00
100	0.159	0.227	0.350	0.469	0.603	0.948	1.369	2.425	3.868	5.443	6.538	7.561	8.659	9.788	10.99	13.70	16.71	20.01
125	.199	.284	.438	.586	.754	1.185	1.712	3.031	4.835	6.803	8.172	9.451	10.82	12.23	13.74	17.12	20.88	25.01
150	.239	.340	.526	.703	.905	1.422	2.054	3.638	5.803	8.165	9.808	11.34	12.99	14.68	16.49	20.55	25.06	30.01
175	.278	.397	.614	.821	1.056	1.660	2.397	4.246	6.772	9.529	11.45	13.24	15.16	17.14	19.24	23.98	29.25	35.03
200	0.318	0.454	0.701	0.937	1.207	1.896	2.738	4.850	7.735	10.88	13.07	15.12	17.32	19.57	21.98	27.39	33.41	40.01
225	.358	.511	.789	1.055	1.358	2.134	3.081	5.457	8.705	12.25	14.71	17.01	19.49	22.02	24.73	30.82	37.59	45.02
250	.397	.567	.876	1.172	1.508	2.370	3.422	6.061	9.668	13.60	16.34	18.90	21.64	24.46	27.47	34.23	41.75	50.00
275	.437	.624	.964	1.289	1.659	2.607	3.765	6.669	10.64	14.97	17.98	20.79	23.81	26.91	30.22	37.66	45.94	55.02
300	0.477	0.681	1.051	1.406	1.811	2.845	4.108	7.277	11.61	16.33	19.62	22.69	25.98	29.37	32.97	41.10	50.12	60.03
325	.517	.737	1.139	1.523	1.961	3.081	4.449	7.881	12.57	17.69	21.24	24.57	28.14	31.80	35.71	44.51	54.28	65.01
350	.557	.794	1.227	1.641	2.112	3.318	4.792	8.488	13.54	19.05	22.88	26.46	30.31	34.26	38.47	47.94	58.47	70.02
375	.596	.851	1.314	1.758	2.263	3.556	5.135	9.096	14.51	20.41	24.52	28.36	32.48	36.71	41.22	51.37	62.65	75.04
400	0.636	0.908	1.402	1.875	2.414	3.792	5.476	9.700	15.47	21.77	26.15	30.24	34.63	39.15	43.96	54.78	66.81	80.02
425	.676	.965	1.489	1.992	2.565	4.029	5.819	10.31	16.44	23.13	27.79	32.13	36.80	41.60	46.71	58.21	71.00	85.03
450	.716	1.021	1.577	2.110	2.716	4.267	6.162	10.91	17.41	24.50	29.42	34.03	38.97	44.05	49.46	61.64	75.18	90.04
475	.755	1.078	1.664	2.226	2.866	4.503	6.503	11.52	18.37	25.85	31.05	35.91	41.13	46.49	52.20	65.05	79.34	95.03
500	0.795	1.135	1.752	2.344	3.017	4.741	6.846	12.13	19.34	27.22	32.69	37.81	43.30	48.94	54.95	68.49	83.53	100.0
525	.835	1.192	1.840	2.461	3.169	4.978	7.190	12.73	20.31	28.58	34.33	39.70	45.47	51.39	57.71	71.92	87.71	105.1
550	.875	1.248	1.927	2.578	3.318	5.214	7.531	13.34	21.27	29.93	35.96	41.58	47.62	53.83	60.44	75.33	91.87	110.0
575	.915	1.305	2.015	2.695	3.470	5.452	7.874	13.95	22.24	31.30	37.59	43.48	49.79	56.28	63.20	78.76	96.06	115.0
600	0.954	1.362	2.103	2.813	3.621	5.689	8.217	14.55	23.21	32.66	39.23	45.37	51.96	58.73	65.95	82.19	100.2	120.1
625	.994	1.418	2.190	2.929	3.772	5.925	8.558	15.16	24.18	34.02	40.86	47.25	54.12	61.17	68.69	85.60	104.4	125.0
650	1.034	1.475	2.278	3.047	3.923	6.163	8.901	15.76	25.14	35.38	42.50	49.15	56.29	63.62	71.44	89.03	108.6	130.1
675	1.074	1.532	2.366	3.164	4.074	6.401	9.244	16.37	26.11	36.74	44.14	51.04	58.46	66.07	74.19	92.46	112.8	135.1
700	1.113	1.589	2.453	3.281	4.224	6.637	9.585	16.98	27.08	38.10	45.76	52.93	60.61	68.51	76.93	95.88	116.9	140.0
725	1.153	1.646	2.541	3.398	4.375	6.874	9.928	17.58	28.05	39.46	47.40	54.82	62.78	70.96	79.68	99.31	121.1	145.1
750	1.193	1.702	2.628	3.515	4.526	7.110	10.27	18.19	29.01	40.82	49.03	56.70	64.94	73.40	82.42	102.7	125.3	150.0
775	1.233	1.759	2.716	3.633	4.677	7.348	10.61	18.80	29.98	42.18	50.67	58.60	67.11	75.85	85.17	106.1	129.5	155.1
800	1.272	1.816	2.804	3.750	4.828	7.585	10.95	19.40	30.95	43.55	52.31	60.49	69.28	78.31	87.93	109.6	133.6	160.1
825	1.312	1.872	2.891	3.867	4.978	7.821	11.30	20.01	31.91	44.90	53.93	62.37	71.43	80.74	90.66	113.0	137.8	165.1
850	1.352	1.929	2.979	3.984	5.130	8.059	11.64	20.61	32.88	46.27	55.57	64.27	73.60	83.19	93.42	116.4	142.0	170.1
875	1.392	1.986	3.067	4.102	5.281	8.296	11.98	21.22	33.85	47.63	57.21	66.16	75.77	85.65	96.17	119.9	146.2	175.1

Note: Volumes are based on an atmospheric pressure of 14.65 lb. per sq. in., uncorrected for deviation from Boyle's law.

Example: A section of 18-in. line is partly blown-down between two main line gates at Stations 1563+49 and 2083+65, respectively. Initial pressure on the section is 750 lb. per sq. in. Pressure on the line at the end of the blow is 175 lb. per sq. in. What is the volume of gast lost during the blowdown?

Solution: 208365 — 156349 = 52016 ft., or 52.016 M ft. of line.

Volume of gas lost in blowdown of 1000 ft. of 18-in. line from 750 lb. per sq. in. ga. to atmospheric pressure = 82.42 M cu. ft.

Volume of gas lost in blowdown of 1000 ft. of 18-in. line from 175 lb. per sq. in. ga. to atmospheric pressure = 19.24 M cu. ft.

Volume of gas lost in blowdown of 1000 ft. of 18-in. line from 750 to 175 lb. per sq. in. ga. pressure = 63.18 M cu. ft.

63.18 times 52.016 = 3286.4 M cu. ft. of gas lost in blowdown

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156H52

VOLUME OF GAS LOST IN BLOWDOWN OF LINE

(Gas volumes in table are in M cu. ft. per 1000 ft. of line)

Initial line pressure on shut-in section, lb. per sq. in., ga.	Nominal diameter of line, in.																	
	2	2½	3	3½	4	5	6	8	10	12	14	15	16	17	18	20	22	24
900	1.431	2.042	3.154	4.218	5.431	8.534	12.32	21.58	34.41	48.62	58.84	68.05	77.93	88.08	98.91	123.3	149.0	178.7
925	1.471	2.099	3.242	4.335	5.582	8.771	12.66	22.18	35.37	49.97	60.47	69.94	80.09	90.53	101.7	126.7	153.1	183.7
950	1.511	2.156	3.329	4.452	5.733	9.008	13.00	22.78	36.32	51.32	62.11	71.83	82.26	92.97	104.4	130.1	157.3	188.6
975	1.551	2.213	3.417	4.569	5.884	9.245	13.35	23.39	37.28	52.67	63.74	73.72	84.42	95.42	107.2	133.6	161.4	193.6
1000	1.590	2.269	3.504	4.686	6.035	9.482	13.69	23.98	38.23	54.02	65.38	75.61	86.59	97.87	109.9	137.0	165.6	198.6
1025	1.630	2.326	3.592	4.804	6.185	9.719	14.03	24.58	39.19	55.37	67.01	77.50	88.75	100.3	112.6	140.4	169.7	203.5
1050	1.670	2.383	3.680	4.921	6.336	9.956	14.37	25.18	40.15	56.72	68.65	79.39	90.92	102.8	115.4	143.8	173.8	208.5
1075	1.710	2.439	3.767	5.038	6.487	10.19	14.72	25.78	41.10	58.07	70.28	81.28	93.08	105.2	118.1	147.3	178.0	213.4
1100	1.749	2.496	3.855	5.155	6.638	10.43	15.06	26.38	42.06	59.42	71.92	83.17	95.25	107.7	120.9	150.7	182.1	218.4
1125	1.789	2.553	3.942	5.272	6.789	10.67	15.40	26.98	43.01	60.77	73.55	85.06	94.41	110.1	123.6	154.1	186.3	223.4
1150	1.829	2.610	4.030	5.389	6.940	10.90	15.74	27.58	43.97	62.13	75.18	86.95	99.58	112.5	126.4	157.5	190.4	228.3
1175	1.869	2.667	4.118	5.516	7.091	11.14	16.09	28.18	44.92	63.48	76.82	88.84	101.7	115.0	129.1	161.0	194.5	233.3
1200	1.908	2.723	4.205	5.623	7.242	11.38	16.43	28.78	45.88	64.83	78.45	90.73	103.9	117.4	131.9	164.4	198.7	238.3
1225	1.948	2.780	4.293	5.740	7.392	11.62	16.77	29.37	46.84	66.18	80.09	92.62	106.1	119.9	134.6	167.8	202.8	243.2
1250	1.988	2.836	4.380	5.857	7.543	11.85	17.11	29.97	47.79	67.53	81.71	94.51	108.2	122.3	137.4	171.2	207.0	248.2
1275	2.028	2.893	4.468	5.975	7.694	12.09	17.46	30.57	48.75	68.88	83.36	96.40	110.4	124.8	140.1	174.7	211.1	253.1
1300	2.067	2.950	4.556	6.092	7.845	12.33	17.80	31.17	49.70	70.23	84.99	98.29	112.6	127.2	142.9	178.1	215.2	258.1
1325	2.107	3.007	4.643	6.209	7.996	12.56	18.14	31.77	50.66	71.58	86.63	100.2	114.7	129.7	145.6	181.5	219.4	263.1
1350	2.147	3.064	4.731	6.326	8.147	12.80	18.48	32.37	51.62	72.93	88.26	102.1	116.9	132.1	148.4	184.9	223.5	268.0
1375	2.186	3.120	4.818	6.443	8.298	13.04	18.82	32.97	52.57	74.28	89.89	104.0	119.1	134.6	151.1	188.4	227.7	273.0
1400	2.226	3.177	4.906	6.560	8.449	13.28	19.17	33.57	53.53	75.63	91.53	105.9	121.2	137.0	153.9	191.8	231.8	278.0
1425	2.266	3.234	4.994	6.677	8.599	13.51	19.51	34.17	54.48	76.98	93.16	107.7	123.4	139.5	156.6	195.2	235.9	282.9
1450	2.306	3.290	5.081	6.794	8.750	13.75	19.85	34.77	55.44	78.33	94.80	109.6	125.6	141.9	159.4	198.6	240.1	287.9
1475	2.346	3.348	5.169	6.915	8.901	13.99	20.19	35.38	56.41	79.69	96.44	111.5	127.7	144.4	162.1	202.1	244.3	292.8

Note: Volumes are based on an atmospheric pressure of 14.65 lb. per sq. in., uncorrected for deviation from Boyle's law.
Values for large-diameter lines at these high pressures are included, looking to the time when they will be needed in actual practice.

Example: A 4864-ft. section of 4-in. is partly blown-down from an initial pressure of 1275 lb. per sq. in. Pressure at the end of the blow is 375 lb. per sq. in. What is the volume of gas lost during the blowdown?

Solution:
Volume of gas lost in blowdown of 1000 ft. of 4-in. line from 1275 lb. per sq. in. ga. to atmospheric pressure = 7.694 M cu. ft.
Volume of gas lost in blowdown of 1000 ft. of 4-in. line from 375 lb. per sq. in. ga. to atmospheric pressure = 2.263 M cu. ft.
Volume of gas lost in blowdown of 1000 ft. of 4-in. line from 1275 to 375 lb. per sq. in. ga. pressure = 5.431 M cu. ft.
5.431 × 4.864 = 26.416 M cu. ft. of gas lost in blowdown.

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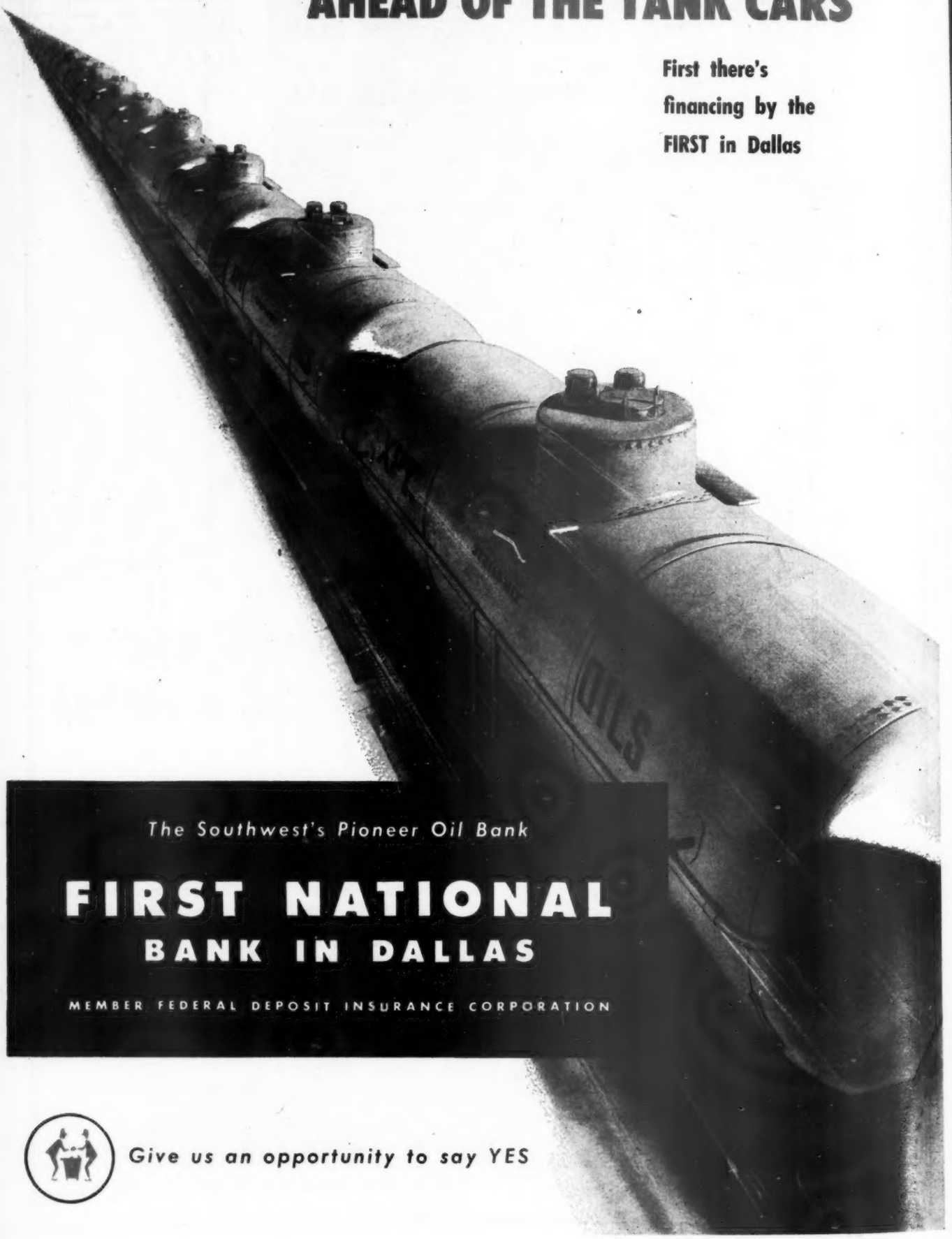

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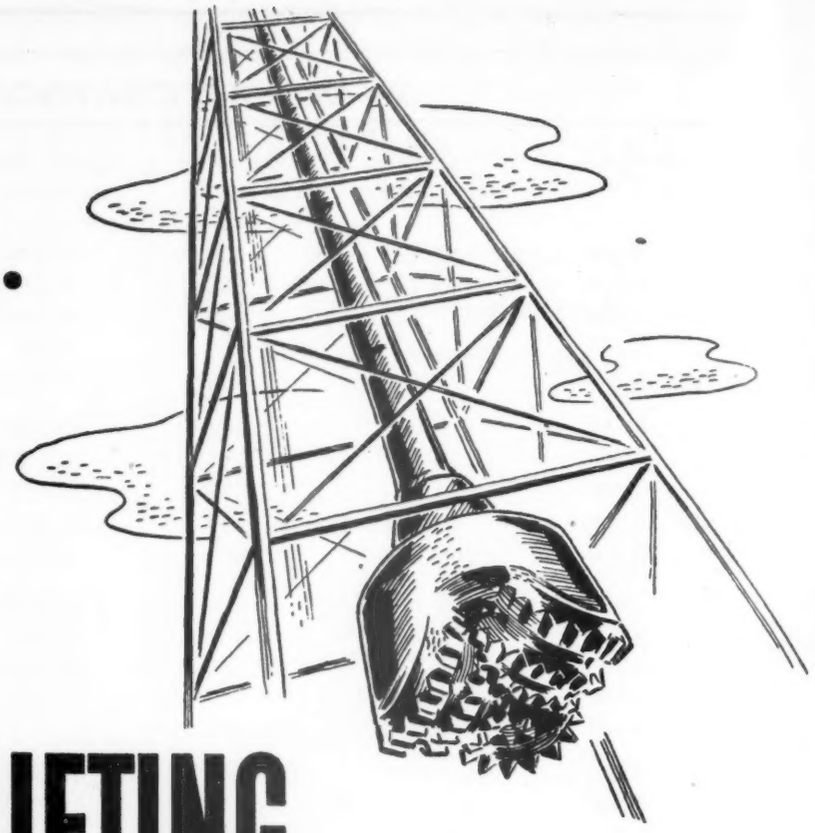
GAS-OIL RATIO CONVERSION TABLE

Gas-oil ratio (cu ft./bbl.)	Yield (bbl./MMCF)	Content (gal./MCF)	Gas-oil ratio (cu. ft./bbl.)	Yield (bbl./MMCF)	Content (gal./MCF)
5,500	181.82	7.636	9,500	105.26	4.421
5,550	180.18	7.568	9,600	104.17	4.375
5,600	178.57	7.500	9,700	103.09	4.330
5,650	176.99	7.434	9,800	102.04	4.286
5,700	175.44	7.368	9,900	101.01	4.242
5,750	173.91	7.304	10,000	100.00	4.200
5,800	172.41	7.241	10,200	98.04	4.118
5,850	170.90	7.179	10,400	96.15	4.039
5,900	169.49	7.119	10,600	94.34	3.962
5,950	168.07	7.059	10,800	92.59	3.888
6,000	166.67	7.000	11,000	90.91	3.818
6,100	163.93	6.885	11,200	89.29	3.750
6,200	161.29	6.774	11,400	87.72	3.684
6,300	158.73	6.667	11,600	86.21	3.621
6,400	156.25	6.563	11,800	84.75	3.559
6,500	153.85	6.462	12,000	83.33	3.500
6,600	151.52	6.364	12,200	81.97	3.443
6,700	149.25	6.269	12,400	80.65	3.387
6,800	147.06	6.177	12,600	79.37	3.333
6,900	144.93	6.087	12,800	78.13	3.281
7,000	142.86	6.000	13,000	76.92	3.231
7,100	140.85	5.916	13,200	75.76	3.182
7,200	138.89	5.833	13,400	74.63	3.134
7,300	136.99	5.753	13,600	73.53	3.088
7,400	135.14	5.676	13,800	72.46	3.044
7,500	133.33	5.600	14,000	71.43	3.000
7,600	131.58	5.526	14,200	70.42	2.958
7,700	129.87	5.455	14,400	69.44	2.917
7,800	128.21	5.385	14,600	68.49	2.877
7,900	126.58	5.317	14,800	67.57	2.838
8,000	125.00	5.250	15,000	66.67	2.800
8,100	123.46	5.185	15,500	64.52	2.710
8,200	121.95	5.122	16,000	62.50	2.625
8,300	120.48	5.060	16,500	60.61	2.545
8,400	119.05	5.000	17,000	58.82	2.471
8,500	117.65	4.941	17,500	57.14	2.400
8,600	116.28	4.884	18,000	55.56	2.333
8,700	114.94	4.828	18,500	54.05	2.270
8,800	113.64	4.773	19,000	52.63	2.211
8,900	112.36	4.719	19,500	51.28	2.154
9,000	111.11	4.667	20,000	50.00	2.100
9,100	109.89	4.615	21,000	47.62	2.000
9,200	108.70	4.565	22,000	45.46	1.909
9,300	107.53	4.516	23,000	43.48	1.826
9,400	106.38	4.468	24,000	41.67	1.750

Example: 10,000 cu. ft./bbl.=100.00 bbl./million cu. ft.=4.200 gal./thousand cu. ft.

Fishtail...
Roller...
Drag...



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GAS-OIL RATIO CONVERSION TABLE

Gas-oil ratio (cu. ft./bbl.)	Yield (bbl./MMCF)	Content (gal./MCF)	Gas-oil ratio (cu. ft./bbl.)	Yield (bbl./MMCF)	Content (gal./MCF)
25,000	40.00	1.680	70,000	14.29	0.600
26,000	38.46	1.615	71,000	14.09	0.592
27,000	37.04	1.556	72,000	13.89	0.583
28,000	35.71	1.500	73,000	13.70	0.575
29,000	34.48	1.448	74,000	13.51	0.568
30,000	33.33	1.400	75,000	13.33	0.560
31,000	32.26	1.355	76,000	13.16	0.553
32,000	31.25	1.313	77,000	12.99	0.546
33,000	30.30	1.273	78,000	12.82	0.539
34,000	29.41	1.235	79,000	12.66	0.532
35,000	28.57	1.200	80,000	12.50	0.525
36,000	27.78	1.167	81,000	12.35	0.519
37,000	27.03	1.135	82,000	12.20	0.512
38,000	26.32	1.105	83,000	12.05	0.506
39,000	25.64	1.077	84,000	11.91	0.500
40,000	25.00	1.050	85,000	11.77	0.494
41,000	24.39	1.024	86,000	11.63	0.488
42,000	23.81	1.000	87,000	11.49	0.483
43,000	23.26	0.977	88,000	11.36	0.477
44,000	22.73	0.955	89,000	11.24	0.472
45,000	22.22	0.933	90,000	11.11	0.467
46,000	21.74	0.913	91,000	10.99	0.462
47,000	21.28	0.894	92,000	10.87	0.457
48,000	20.83	0.875	93,000	10.75	0.452
49,000	20.41	0.857	94,000	10.64	0.447
50,000	20.00	0.840	95,000	10.53	0.442
51,000	19.61	0.824	96,000	10.42	0.438
52,000	19.23	0.808	97,000	10.31	0.433
53,000	18.87	0.793	98,000	10.20	0.429
54,000	18.52	0.778	99,000	10.10	0.424
55,000	18.18	0.764	100,000	10.00	0.420
56,000	17.86	0.750	105,000	9.52	0.400
57,000	17.54	0.737	110,000	9.09	0.382
58,000	17.24	0.724	115,000	8.70	0.365
59,000	16.95	0.712	120,000	8.33	0.350
60,000	16.67	0.700	125,000	8.00	0.336
61,000	16.39	0.689	130,000	7.69	0.323
62,000	16.13	0.677	135,000	7.41	0.311
63,000	15.87	0.667	140,000	7.14	0.300
64,000	15.63	0.656	145,000	6.90	0.290
65,000	15.39	0.646	150,000	6.67	0.280
66,000	15.15	0.636	155,000	6.45	0.271
67,000	14.93	0.627	160,000	6.25	0.263
68,000	14.71	0.618	165,000	6.06	0.255
69,000	14.49	0.609	170,000	5.88	0.247

Example: 100,000 cu. ft./bbl.=10.00 bbl./million cu. ft.=0.420 gal./thousand cu. ft.

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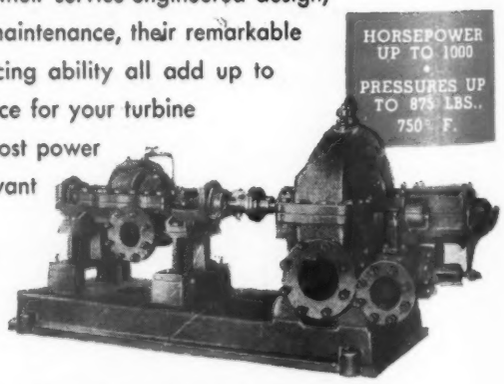

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GAS-OIL RATIO CONVERSION TABLE

Gas-oil ratio (cu. ft./bbl.)	Yield (bbl./MMCF)	Content (gal./MCF)	Gas-oil ratio (cu. ft./bbl.)	Yield (bbl./MMCF)	Content (gal./MCF)
175,000	5.71	0.240	500,000	2.00	0.084
180,000	5.56	0.233	550,000	1.82	0.076
185,000	5 41	0.227	600,000	1.67	0.070
190,000	5.26	0.221	650,000	1.54	0.065
195,000	5.13	0.215	700,000	1.43	0.060
200,000	5.00	0 210	750,000	1.33	0.056
205,000	4.88	0 205	800,000	1.25	0.053
210,000	4.76	0 200	850,000	1.18	0.049
215,000	4 65	0.195	900,000	1.11	0.047
220,000	4.55	0.191	950,000	1.05	0.044
225,000	4.44	0.187	1,000,000	1.00	0 042
230,000	4 35	0 183	1,100,000	0.91	0.038
235,000	4.26	0.179	1,200,000	0.83	0.035
240,000	4.17	0.175	1,300,000	0.77	0.032
245,000	4.08	0.171	1,400,000	0.71	0.030
250,000	4 00	0.168	1,500,000	0.67	0.028
255,000	3.92	0 165	1,600,000	0 63	0 026
260,000	3.85	0.162	1,700,000	0.59	0 025
265,000	3 77	0 159	1,800,000	0.56	0.023
270,000	3.70	0.156	1,900,000	0.53	0.022
275,000	3.63	0 153	2,000,000	0.50	0.021
280 000	3.57	0 150	2,100,000	0.48	0.020
285,000	3.51	0.147	2,200,000	0.46	0 019
290,000	3.45	0 145	2,300,000	0.44	0.018
295,000	3.39	0.142	2,400,000	0.42	0.018
300,000	3.33	0.140	2,500,000	0.40	0.017
310,000	3.23	0.135	2,600,000	0.38	0.016
320 000	3.13	0.131	2,700,000	0.37	0 016
330,000	3.03	0.127	2,800,000	0 36	0.015
340,000	2 94	0.124	2,900,000	0.34	0.014
350,000	2.86	0.120	3,000,000	0.33	0.014
360 000	2.78	0.117	3,500,000	0.29	0.012
370,000	2.70	0 114	4,000,000	0.25	0 011
380 000	2.63	0 111	4,500,000	0.22	0.009
390,000	2.56	0.108	5,000,000	0.20	0.008
400,000	2.50	0.105	5,500,000	0.18	0.008
410,000	2.44	0 102	6,000,000	0 17	0 007
420 000	2.38	0.100	6,500,000	0 15	0.006
430,000	2 33	0.098	7,000,000	0.14	0.006
440,000	2.27	0.095	7,500,000	0.13	0.006
450,000	2.22	0.093	8,000,000	0.13	0.005
460 000	2 17	0.091	8,500,000	0 12	0.005
470,000	2.13	0 089	9,000,000	0 11	0.005
480,000	2 08	0.088	9,500,000	0.11	0.004
490,000	2.04	0.086	10,000,000	0.10	0.004

Example: 500,000 cu. ft./bbl.=2.00 bbl./million cu. ft.=0.084 gal./thousand cu. ft.

LAUGH with BARNEY

The minister had been asked to present the prizes to the winners of the local dog show, but when he got there he was outraged at the dress of some of the girls.

"Just look at that young person there with the cigarette, close-cut hair, and breeches," he cried to a bystander. "Is it a boy or girl?"

"It's a girl," replied the other. "She's my daughter."

"Oh, forgive me, sir," apologized the preacher, "I never dreamed you were her father."

"I'm not," was the reply, "I'm her mother."

* * *

An old colored preacher was praying with great oratorical effect in the midst of a violent hurricane. As the earth quivered and the heavens roared, he cried out, "Send us the spirit of the children of Israel, the Children of Moses and the children of the Promised Land."

An old darkey with less oratory but more directness said, "Lord, don't send nobody. Come yourself! This ain't no time for chillun!"

* * *

It takes two to make a marriage—a single girl and an anxious mother.

* * *

"You tell 'em, Wells Fargo, I can't express it."

Four Marines were playing bridge on Guadalcanal when another burst wildly into the place, shouting:

"Hey, guys, the Nips have landed a force of about 200 men down on the beach!"

The players looked at one another. Apathetic silence reigned over all. Finally one said, "Never mind, boys, I'll go. I'm dummy this hand, anyway.."

* * *

Maybe the school-boy was right when he wrote: "Excises are what Uncle Sam takes to keep him fiscally fit."

* * *

A story is told of a young man who called one evening on a rich old farmer to learn the farmer's story of how to become rich.

"It's a long story," said the old man, "and while I'm telling it, we might as well save the candle." And he blew it out.

"You needn't go on," said the youth. "I understand."

* * *

A man and his wife whom a Jackson, Mich., policeman caught with a five-gallon can of bootlegged moonshine in a baby carriage, were at a loss to explain the mystery.

"Amazing!" they said. "We were almost sure it was the baby when we left home."

Matilda says: The Lord made us beautiful and dumb—beautiful so the men would love us and dumb so we would love them.

* * *

A foreign newspaper correspondent reported this dialogue, reputedly direct from the Kremlin.

"What," asked the first Russian, "was the nationality of Adam and Eve?"

"There's no possible doubt, they were Soviet citizens," replied the second Russian. "They had nothing to wear, nothing to eat but an apple and lived in paradise."

* * *

Wife: Don't you think, dear, that a man has more sense after he's married?

Husband: Yes, but it's too late then.

* * *

(Editor's Note: S. Chisum, Stanolind Oil and Gas, Greggton, Texas, says that he found the following among papers that belonged to his grandfather. The original copy was so old it fell apart when lifted from the box. The article was written about 1914.)

A couple about to be married were looking for a house in the country. After satisfying themselves that a certain house was suitable, they made their way home. During their trip home the young lady asked "Did you see any WC?" (meaning water closet) Not having noticed any they wrote to the landlord asking where it was located. The landlord did not know what WC meant and after thinking it over decided that it meant Weslyan Church and answered as follows:

Dear Sir:

I very much regret the delay in this matter but have much pleasure in informing you that the WC is situated nine miles from the house and is capable of seating 250 people at one time. This is very unfortunate for you if you are in the habit of going regularly, but no doubt you will be glad to know that a great many people take their lunch with them and make a day of it while others who cannot spare the time go by car and are just in time but are generally in too great a hurry to wait. Last time my wife and I went was six years ago and we had to stand all the time. It may be of interest to you to know that the management is about to have a bazaar to furnish the WC with plush as the members feel this a long felt want. I may mention that it pains me very much to not be able to go more frequently. Hoping this may interest you I am

Yours very truly,
A. Toby

P.S. If you are not satisfied with the above arrangements I might inform you that some people use Christian Science and never go at all.

* * *

Willie Sutton, recently apprehended criminal, when asked why he robbed banks: "I rob banks because that's where the money is."

* * *

If Patrick Henry thought taxation without representation was bad, he should see it *with* representation.—UMW Journal.

Panoramic view of the 1953 International Petroleum Exposition site. This scene was taken during the 1948 oil show in Tulsa, Oklahoma. The 1953 show will include an additional 35,000 sq ft of exhibition space and will be available to exhibitors November 1. The show is scheduled to run from May 14 to May 23.

ADDITIONAL space is being sought to take care of the unprecedented demand for exhibit facilities at the 1953 International Petroleum Exposition, according to announcement by William B. Way, general manager. Way said requests and inquiries indicate that between 150 and 250 more oil equipment and service firms will contract for space at the May 14-23, 1953, show than have exhibited at any previous exposition.

There were 574 contracts for space at the last show, held in 1948, which represented more than 1000 companies. A total of 628 space contracts have already been signed for the 1953 show, according to Way.

The housing committee, headed by Barton A. Myers, reports that over 750 houses, ranging from two to five bedrooms, have been listed for rent during the show and that oil companies are now leasing these. Those wishing houses or hotel rooms should contact the IPE Housing Bureau, 616 South Boston, Tulsa.

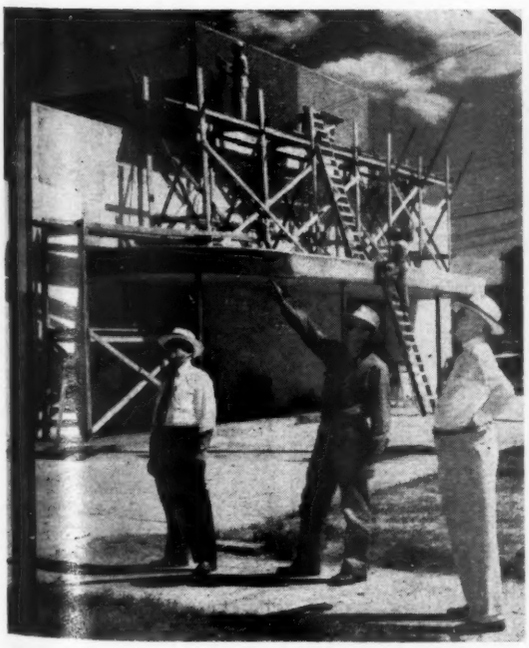
The exposition has purchased for rental to exhibitors and has stored over $50,000 worth of chrome and leather furniture. Sewer, water, and electric lines have been completed in the first new exhibit space section. Two-thirds of the work of the $100,000 renovation and repair program for the IPE grounds is now complete.

Rent forms, with an insurance provision, are available through the Housing Bureau, Meyers reports.

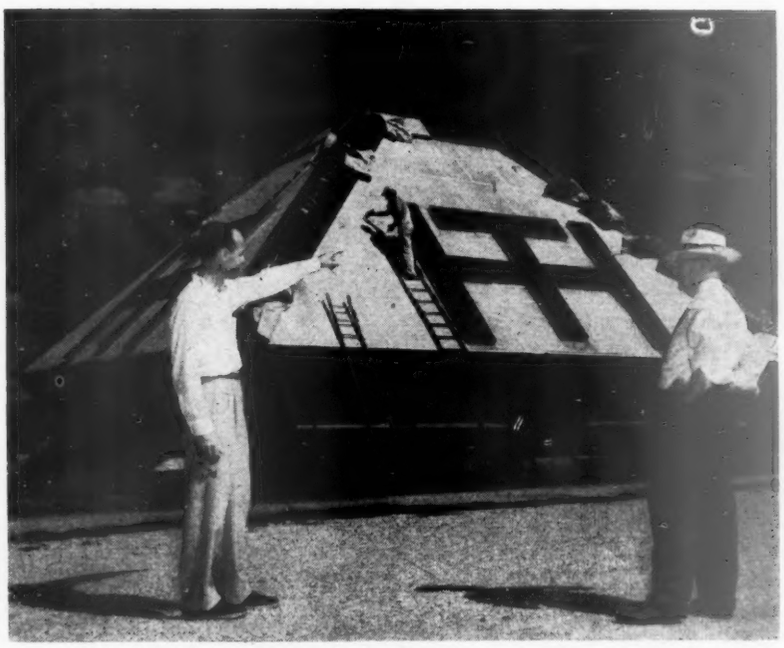
"The exposition management is doing all in its power to provide all the exhibit space needed and we hope those unable to obtain space thus far will bear with us until we can create suitable space," Way said. "All legitimate firms will be able to get space before the show opens."

Oil Show Preparations Underway

Additional space being sought for 1953 International Petroleum Exposition at Tulsa, Oklahoma, as demands exceed expectations

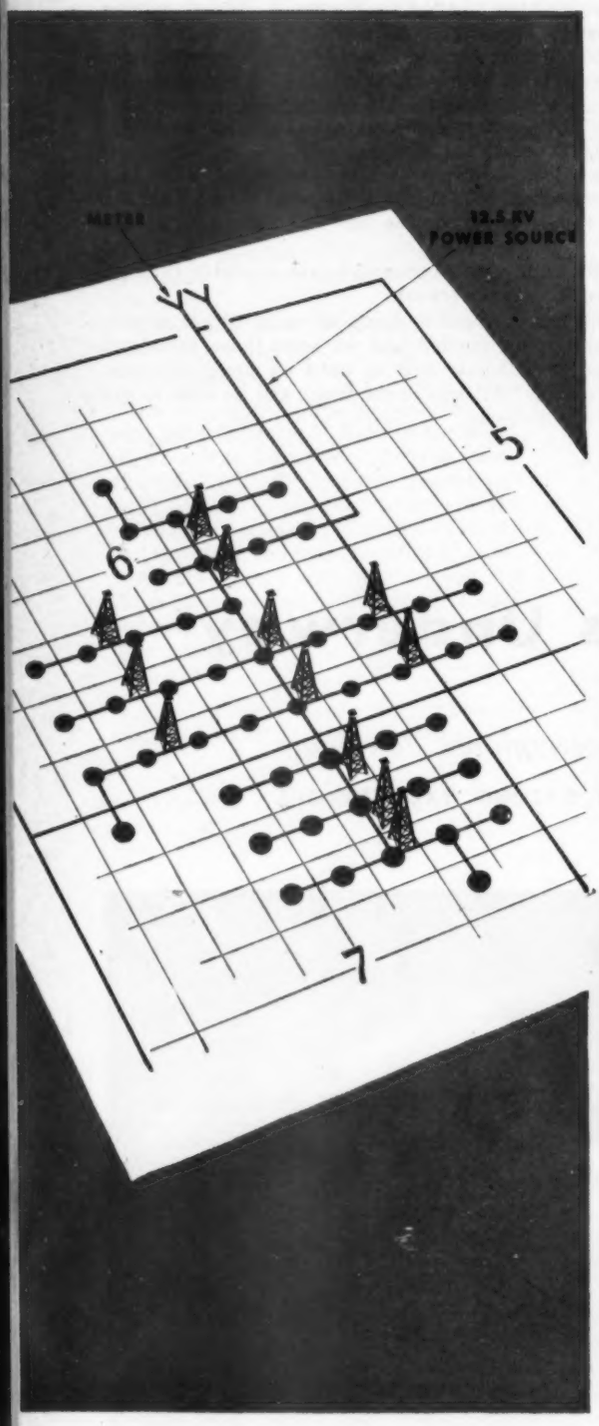


Workmen are shown renovating and repairing one of the buildings at the exposition site. Frank J. Hinderliter, vice president of the exposition is shown left with William B. Way, general manager.



The unique Hughes Tool Company-owned building is shown under renovation. The building is shaped like the Hughes Tool Company emblem. It will be fully air conditioned. Observing the work are Frank J. Hinderliter (right), and B. A. Bridenthal, exposition office manager.

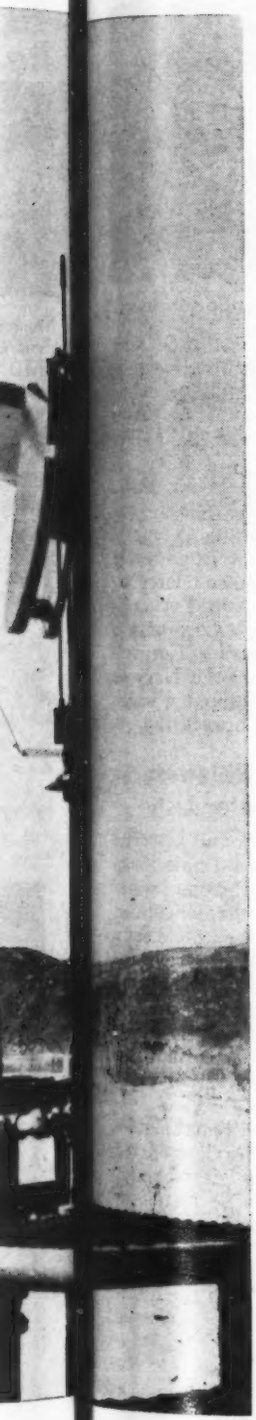
They did what you can do to reduce costs



Cost of the complete power line for these 49 Oklahoma wells was only $378 per well. Pumping cost is only 4.1c per bbl.

This Westinghouse-equipped pumping rig operates in *blowing sand* in a dry river bed. However, it has given 100% performance!

An opportunity for major cost savings in petroleum production



Have you really studied the dollar and cents advantages of electrified pumping? Look at these two examples from the Westinghouse files.

Operates under severe conditions

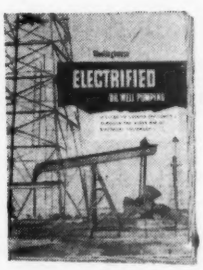
The photo at left shows a rig mounted on stilts in a dry river bed in Texas. The service conditions are terrible—sand blows constantly except during the rainy season when the river bed floods. Yet the Westinghouse motor and automatic time control have given 100% performance since they were installed two years ago. They haven't even required contact replacement. The automatic control cuts the motor in and out as desired, with just a rare check by the pumper.

Pumps 49 wells for only 4.1c per bbl

But you don't have to have unusually severe conditions to make electrified pumping pay. A study of 49 wells in the Healdton field in Oklahoma, shows pumping costs of *only 4.1c per bbl.* Westinghouse automatic time control staggers the pumping load so that power load is just 47% of total connected load. The whole 49 wells are handled by one combination pumper-electrician. And the installed cost of the power line was only $378 per well, including transformers.

Call Westinghouse for planning help

Determining the best pumping method over the long run requires a careful economic analysis. It's a costly mistake to select equipment simply on the basis of what is easiest or cheapest to set up initially. Westinghouse would like to help you make the type of study that will show whether *you* can make major cost savings in your petroleum production. Call us in.

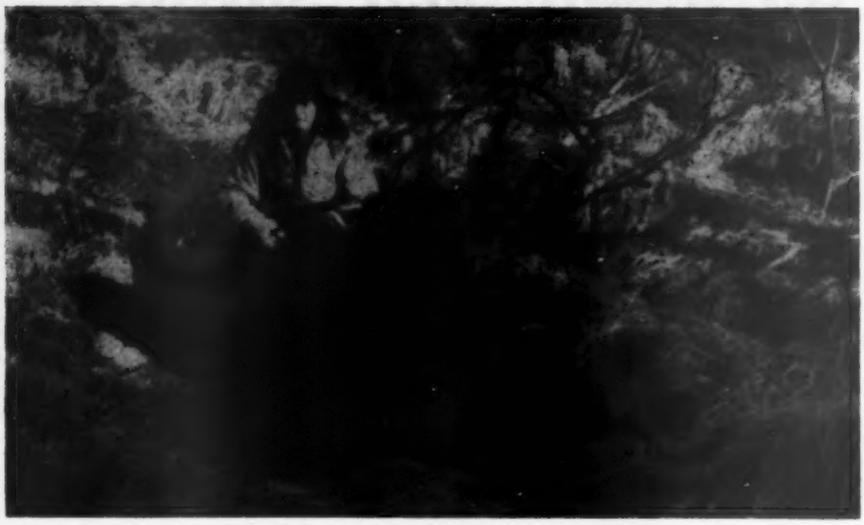


DO YOU HAVE YOUR COPY of this valuable guide on oil well pumping? Write for B-4039, "Electrified Oil Well Pumping," Westinghouse Electric Corp., P.O. Box 868, Pittsburgh 30, Pa.
J-94908

YOU CAN BE SURE...IF IT'S
Westinghouse

EQUIPMENT FOR THE PETROLEUM INDUSTRY

OIL and GAS TRADE NEWS



Alaska Hunting Depicted. Daniel Orifice Fitting Company employees and their families were entertained at a company party recently by Paul F. Daniel, president. Entertainment was a color film of a recent bear hunting trip to Kodiak Island in Alaska made by Daniel. Above is Daniel and the first of the three bears killed by the hunters, a 1400-lb specimen with a skin size of 10 ft 6 in. A buffet supper was served after the movie.

BJ Sets Up Montana Stations

New stations at Williston, North Dakota, and Glendive, Montana, have been opened by BJ Service, Inc., to keep pace with the increased oil activity in the Rocky Mountain area, according to John B. Merritt, executive vice president and general manager. The two additions bring the total of BJ Service, Inc., stations in the Rocky Mountain area to five. Curtis M. Jenkins is in charge of operations at Williston. At the new Glendive station, L. N. Tholkes has been selected to direct operations.

Mission Manufacturing Company's A. L. Jacobs, left, purchasing agent, receives a certificate of award from J. T. McSpadden of Magnolia Paper Company for the Mission E-Z swab box, manufactured by Magnolia, which won recognition at the 1952 Setup Paper Box Competition of the National Paper Box Manufacturers Association held in Chicago recently. The Mission award was the only one given to a member of the oil industry.

Drayer-Hanson Buys Jackson Engineering

Recently announced was the purchase of the Jackson Engineering Company, by Drayer-Hanson, Inc., Los Angeles, California. George J. Morton, president of Drayer-Hanson stated that the appointment of Gordon M. Jackson as vice president of the industrial division places the company in a highly specialized field following the present defense program. He continued, "Jackson has complete charge of mechanical design, selection, and sales engineering of all heat transfer equipment offered for use in engine cooling systems, gasoline refineries, power plants, and other industrial applications."

Gordon Jackson

Jackson was graduated from Annapolis in 1918. From 1923 to 1926. he was sales manager of C. F. Braun Company, before forming the Jackson Engineering Corporation in 1927. Jackson later set up his own business as New York representative for the Fluor Corporation, Struthers Wells and Girdler Corporation. After discharge from the Navy he established the Cal-Fin Company, which later became Jackson Engineering.

Layne and Bowler Releases Film on Ground Water Use

Layne and Bowler, Inc., and associate companies have completed a new 16mm picture with narration on ground water development. The picture, entitled "Deep Water," depicts a complete story of well water development from the initial survey through engineering, construction, testing, and actual use, including "on the scene shots" of Layne men and equipment at work on water development projects, and other interesting scenes.

This picture not only will enable sales engineers to portray the services offered by Layne ground water development companies, but also will be an aid to engineering schools, governmental departments, municipal planning boards, clubs, and many other individuals and organizations concerned with the development of ground water for domestic and commercial uses.

The Layne motion picture, "Deep Water," is available for showing without cost to city councils, engineering clubs, schools, colleges, governmental agencies and departments, and others interested in ground water development.

Further information may be obtained about the new film by writing to Layne and Bowler, Inc., P. O. Box No. 6697, Hollywood Station, Memphis 8, Tennessee.

Lane-Wells Company executives and general sales engineers met in Oklahoma City recently for the 1952 general sales conference. Plans for the coming year were presented by James D. Hughes, general sales manager, and review of the past year by Rodney S. Durkee, president.

Sales Agents Named

Superior Combustion Industries, Inc., of New York City, announces the appointment of Johnson-Heyck, Inc., Houston, Texas, as sales representatives to

T. R. Heyck

C. D. Johnson

handle the sales of Superior heat exchangers in the state of Texas. Both Curtiss D. Johnson and Ted R. Heyck have a wide background in industrial sales with an emphasis on heat transfer equipment.

Canadian Branch Set Up

Opening of a new service branch at Grande Prairie, Alberta, Canada, was announced recently by the Canadian division headquarters of the McCullough Tool Company, Edmonton, Alberta. The new branch has been placed in charge of John H. Williams who began his career in 1930 at Turner Valley, Alberta. Since then he has worked for 19 years in Canadian oil fields. Williams joined McCullough as a field service engineer in 1951.

Mead Engine Is Agent

Appointment of Mead Engine and Welding Works, Sterling, Kansas, as an industrial distributor for Nordberg 4FS diesel engines is announced by Nordberg Manufacturing Company, Milwaukee, Wisconsin. Located centrally in the state, this firm will cover all of Kansas except the northeast section for Nordberg. The Mead organization has excellent service facilities and a new office building with sales and parts room for the Nordberg 4FS engines will be erected shortly.

LaPlant-Choate Reorganizes

The board of directors of LaPlant-Choate Manufacturing Company, Inc., Cedar Rapids, Iowa, has approved an agreement and plan of reorganization with Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin.

The plan had been approved previously by directors of Allis-Chalmers. Acquisition of LaPlant-Choate will broaden the industrial line of the tractor division of Allis-Chalmers in earthmoving and other fields.

Fifty Tank Cars Ordered

The Solvay Process Division of the Allied Chemical and Dye Corporation has placed an order with the American Car and Foundry Company for fifty 70-ton, class 105-A-300W tank cars, to be built at the ACF Milton, Pennsylvania plant. The cars will have a capacity of 110,000 pounds of chlorine.

Incorporation Announced

L. S. Barksdale announces the incorporation of Barksdale Valves and the promotion of M. C. Nelson from general

L. S. Barksdale

M. C. Nelson

manager to vice president and director of the Barksdale organization.

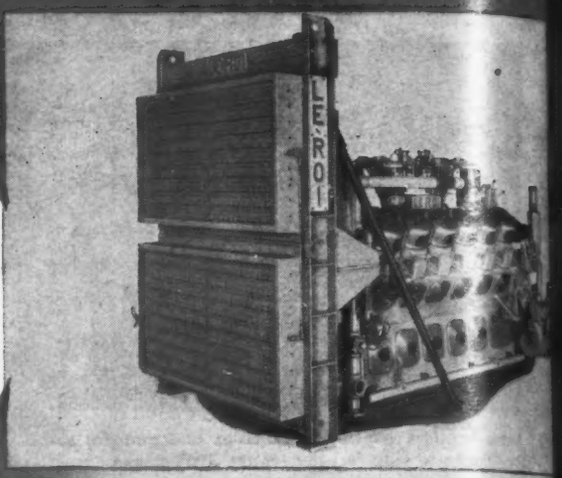
In his new position Nelson will direct the expanding sales activities of the corporation, which is now represented in 40 major industrial areas.

New Naphthalene Produced

The Productol Company of Los Angeles, California, has added 78-deg Naphthalene to its growing list of chemical products now being manufactured commercially on the West Coast. Tank-car shipments are now being made from Productol's newly constructed plant at Santa Fe Springs, California. The company's previous activity has been restricted to the manufacture of cresylic acids and the separation and purification of such components as phenol, ortho cresol and meta para cresol.

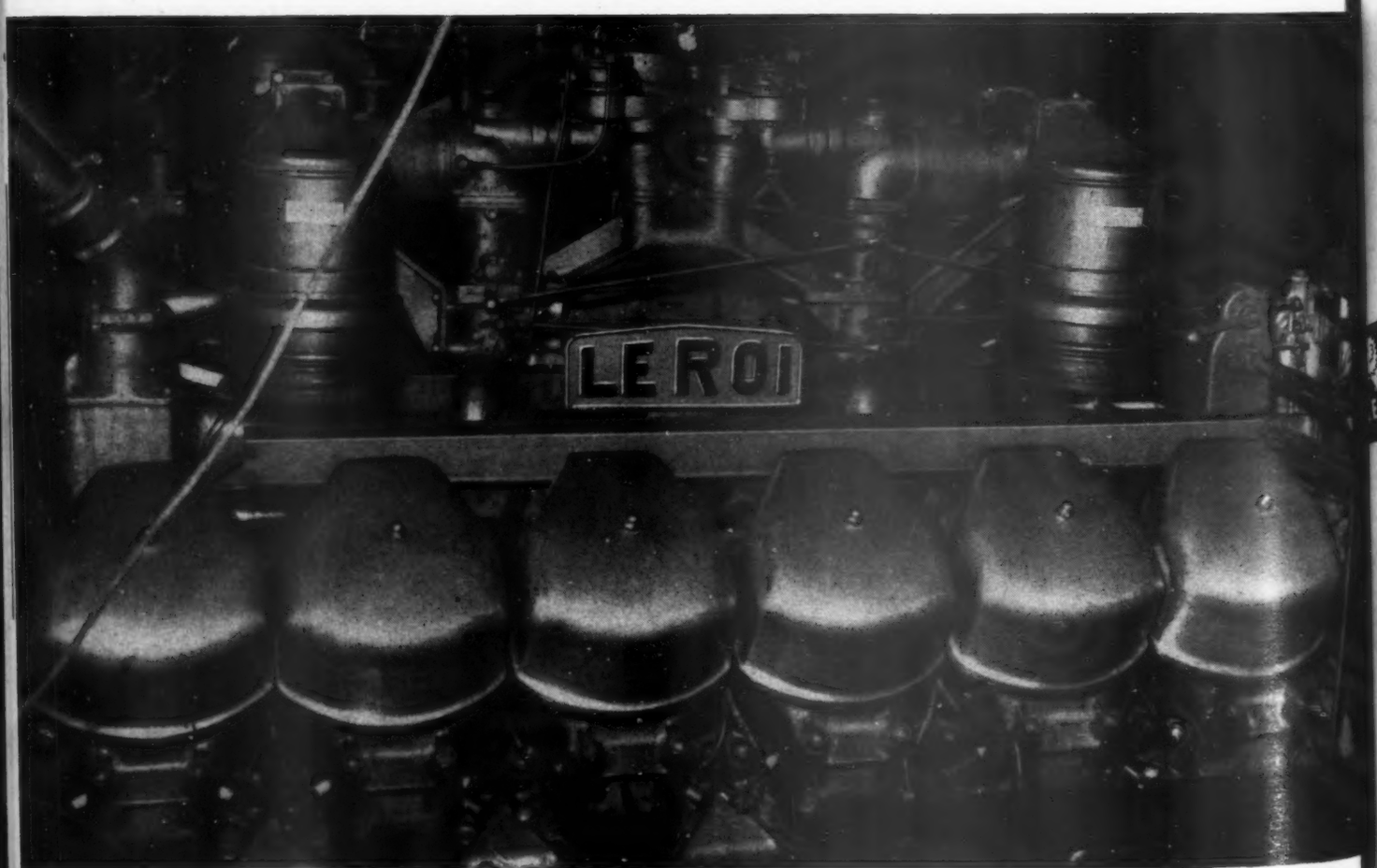
Well Equipment Manufacturing Corporation held its annual sales meeting in Odessa, Texas, recently, more than 500 miles from the home office in Houston. Seen on its visit to a rig in West Texas is the entire group attending the meeting. They are: Sales managers John W. Gates, Weco, and G. R. Winder, Chicksan; A. H. Watts, representative, Weco; Frank Wiegand, field engineer, Walt Berntsen, sales representative, and Gus M. Bagnard, chief engineer, Chiksan; J. C. McCelvey, representative, Weco; Bev Ragsdale, representative, Chiksan; Bill Brien, Roy Shields, Eli Parker and Bill Hull, representatives, Weco; Jack Runnells, Canadian representative, Chiksan; Durk Durkin, representative, Weco; Pete Bily, product development engineer, Chiksan; J. H. Robinson, general manager, Weco; I. D. Abshire, Charley Gisler, Harry Rogers and Jimmy Llewellyn, representatives, Weco; Chuck Holcomb, special representative, Weco, and Foster Jordan, assistant sales manager, Weco, and company tool pusher.

Le Roi 3-way partnership



1 Better Engines. Men from one of the southwest's largest drilling contractors call Le Roi's L3460 "the finest oil-field engine ever made!" 15 of their 19 rigs are powered by Le Roi L3460 or RX Series engines. That's typical of the oil field's endorsement of Le Roi's progressive design policies.

You come out of the h



Jack Grace Drilling Co. uses 2 Le Roi L3460's to power their rig. In drilling to 9,100 feet, they use 5" drill pipe which makes hoisting load equivalent of 15,000 feet of 4½" pipe.

2 Better Applications. Exclusive Le Roi distributors and factory men are oil-field power specialists. They know engines. That's why they can select the right power unit for any application. That's why you can bank on Le Roi for dependable, low-cost power.

3 Better Service. Ample factory, branch office, and distributor parts stocks mean minimum downtime for repairs. Skilled service men are ready to go 24 hours a day. Keeping your Le Roi engines running is a recognized responsibility.

hole fast!

two Le Roi L3460's hoist 5" pipe from 8300 ft. on wet trip in just two hours!

This recent experience of Jack Grace Drilling Co., Wichita Falls, Texas, is just one demonstration of what the Le Roi L3460's extra power can do. Reports from all fields show that when you need power — fast! — you can count on your Le Roi L3460's.

They are conservatively rated — have plenty of reserve power to pull you out of the tight spots. And they respond to the throttle lightning-fast for hoisting service.

Here you have oil-field power at its best: A wide speed range from 600 to 1350 rpm. Horsepower from 350 to 600 max. Lugging power at slow speeds. Compactness that helps you keep over-all width and weight limitations. Dependability and economy under continuous loads. Like all Le Roi engines, the L3460 operates on the most economical fuels in the oil fields — natural gas and butane.

Ask your rig manufacturer, supply house, or Le Roi distributor to show you L3460 and other Le Roi engine installations — or write us. See for yourself why you're way ahead of the field, when you let Le Roi's 3-way partnership work for you.

LE ROI COMPANY

MILWAUKEE 14, WISCONSIN
Plants: Milwaukee • Cleveland • Greenwich, Ohio
Oil Field Headquarters: Tulsa, Oklahoma

See these Le Roi Distributors for a Profitable 3-way Partnership

Oklahoma
Le Roi Company Branch — Tulsa
Carson Machine & Supply Co.— Oklahoma City

East & South Texas, Gulf Coast
Southern Engine and Pump Company — Houston, Kilgore, Edinburg, Dallas, San Antonio, Corpus Christi, Texas, and Lafayette, Houma, Louisiana.

North & West Texas, New Mexico
General Machine & Supply Co. — Odessa, Snyder, Texas.
Nortex Engine & Equipment Co.—Wichita Falls, Texas.

Kansas
Carson Machine and Supply Co.—Great Bend

Illinois — Western Kentucky
Western Machinery & Engine Company — Centralia, Illinois and St. Louis, Missouri.

Michigan
Hafer Engine Service — Reed City

Rocky Mountain Area
Gehring Equipment Co. — Casper, Wyoming, Rangeley, Col.

Mississippi, Arkansas and Northern Louisiana
Ingersoll Corporation — Shreveport, Louisiana, Jackson, Mississippi, El Dorado, Arkansas

West Coast
Le Roi-Rix Machinery Co. — Los Angeles, Long Beach and Bakersfield, Calif.

Appalachian Area
P. C. McKenzie Co., Pittsburgh, Bradford.

Canada
Lucey Export Ltd. — Calgary, Edmonton, Alberta.

P-114

A Typical Le Roi Service Facility

This service shop, equipped with the finest tools available for engine overhaul, belong to the Gehring Equipment Co., Casper, Wyoming. Gehring provides prompt service to an area stretching from the southern boundary of Colorado to the Canadian border. They maintain the only complete engine parts stock in the Rocky Mountain area. Emergency cases are handled by plane. It is because of service like this that you can always depend on Le Roi.

YOU'LL DO IT BETTER WITH Ledeen CYLINDERS

WHEREVER YOU HAVE TO...

PUSH or PULL
LIFT or LOWER
PRESS or SQUEEZE
TILT or TURN
OPEN or CLOSE

Ledeen cylinders used for air, oil, water, gas or steam operation with medium, heavy or super-duty models, provide a large number of variations and adaptations to meet your specific power or motion requirements. They are available in many diameters and stroke lengths with suitable head and rod attachments to provide almost any desired mounting.
Standard Ledeen cylinders and mountings from distributors' stocks in major cities. Special cylinders if required. All J.I.C.

WRITE FOR BULLETIN 500

VALVES • CYLINDERS
AIR-HYDRAULIC PUMPS & BOOSTERS
VALVE ACTUATORS • AIR HOISTS

Ledeen Mfg. Co.
1608 San Pedro
Los Angeles 15, Calif.

Trade News

New Filtrol Plant Set

Wright W. Gary, president of Filtrol Corporation, announces the construction in the immediate future of a new $5,000,000 Filtrol plant at Vernon, California, to manufacture ammonium sulfate fertilizer and high purity alumina. This plant will further process the alumina to produce alumina catalyst, stabilized alumina catalyst, and impregnated alumina catalyst. Engineering and design of Filtrol's new plant has been awarded to the J. H. Pomeroy Company, Inc., of San Francisco. Actual construction is scheduled to commence during the fourth quarter of 1952 and completion is expected in the fourth quarter of 1953.

Cleco Appoints Agents

The Cleco Division of the Reed Roller Bit Company, Houston, Texas, has announced the appointment of Harry P. Leu, Inc., Orlando, Florida; and Ace Equipment and Supply Company, Inc., 436 Irving Avenue, Hillside, Illinois, as distributors for Cleco products in their areas.

Mid-Continent Supply Announces Two New Stores

A new store in Seminole, Oklahoma, and a relocated store with increased capacity in Shreveport, Louisiana, have been announced by Ken W. Davis, president of Mid-Continent Supply Company. New Seminole store is situated on U.S. Highway 270 half a mile north of the Seminole business district. An important feature of the location is the 10,000 sq ft paved parking area around the store. W. H. Haney is manager of the Seminole store. Field salesmen are D. E. Rowe and T. R. Wilson. Storemen include J. D. Brown, H. R. Gamble, D. O. Jackson, and S. L. Rooker.

The Shreveport store is headed by C. R. Lowry, store manager. His staff includes Durward Rust, J. R. Cunningham, M. E. Wilkinson, and R. H. Martin as salesmen, W. P. Wilson, J. R. Timmons, G. L. Sylvester, and Paul Acker as storemen, and Linzey Ware, porter. Betty Ruth Dodson is secretary-receptionist. Seminole store is under the district managership of J. P. Alexander in Oklahoma City.

Parker Is New Western Head

Chemical plants division of Blaw-Knox Company has expanded and reorganized its Tulsa, Oklahoma, office into a complete operating unit to be known as the Western headquarters, and has appointed F. Drake Parker its manager. His responsibilities as manager of the Western headquarters will include the direction of a staff that presently includes some 100 engineers. A graduate of the University of Michigan, Parker was formerly with Badger Process Division of Stone Webster Engeneering Corporation.

F. D. Parker

Process Heating Seminar Held

The third annual John Zink Process Heating Seminar was held Saturday, October 4, 1952, at the John Zink plant, Tulsa, Oklahoma. Purpose of the Seminar, according to Robert Reed, chief engineer of the John Zink Company and organizer of the Seminar, was to provide practical supplemental material directed toward improvement in plant operation more specifically than toward theoretical approach to the many problems of the process industries. J. J. B. Rutherford of the Babcock and Wilcox tubular products division, read the first paper, which dealt with tube failures in process heaters. A second paper, covering various aspects of fractionating tower design and maintenance with particular emphasis on the effect of heat level in the presence of various corrosive materials normally met in process work, was read by R. W. Fowler of Fritz W. Glitsch and Sons.

The "blistering" of catalytic process vessels, a new problem was presented in the third paper by C. E. Rawlins, Phillips Petroleum Company, an author who has done extensive work and research on this matter. Alloy castings for heat and corrosion resistance provided the subject for the fourth paper, read by E. A. Schaefer of the Alloy Castings Institute.

W. C. Norris Company held its annual sales meeting recently at the home offices and plant in Tulsa, Oklahoma. Attending were: *Seated,* M. L. Parker, J. W. Whitaker, J. E. Giles, Arthur Miller, Jr., Jack Getty, A. C. Cloud, G. W. Davidson, LeRoy Mitchell, and K. M. Cook. *Standing:* Jack Schaff, D. P. Hagaman, A. L. Ethriedge, Clyde C. Sights, J. W. Bowen, C. N. Snelling, Ricard Ohrstrom, A. A. Hardy, Cecil Fair, D. W. Stewart, W. C. Tolleson, and C. B. Schofield.

Halliburton officials are: John Guest, chief engineer; Frank Hogwood, architect; Logan D. Campbell, vice president and secretary-treasurer; W. R. McClendon, president, and R. M. "Dick" Hansen, coordinator. In background are Halliburton Plant Two buildings.

Halliburton Builds Technical Center

Work has begun on Halliburton Oil Well Cementing Company's new technical center at Duncan, Oklahoma, W. R. McClendon, president, has announced. The six-acre technical center will house Halliburton's engineering, laboratory, and research facilities. Over one hundred engineers, chemists and other technical personnel will transfer to the Center when it is completed.

Architects for the building are Coston and Frankfurt, Oklahoma City. General contractors are O. C. Bass and Sons, Enid, Oklahoma. Estimated completion date is June 1, 1953.

Baker Oil Tools Hosts to Tulsa Purchasing Agents

Baker Oil Tools, Inc., held the 19th anniversary reception and dinner for the Purchasing Agents Association of Tulsa recently at the Tulsa Club.

After the dinner an interesting motion picture was shown, entitled, "Success Story" as it originally appeared on Richfield Oil Company's Southern California radio program, which won a *Life Magazine* award. Included in the picture are views of the new million dollar Baker structure, where Baker tools are manufactured. Also, interviews with R. C. Baker, Sr., founder of the company, now in his 80th year and still active; T. Sutter, vice president and general manager, who demonstrates some of the tools, and Bill Althouse, chief engineer.

The Purchasing Agents Association of Tulsa presented for the first time in the Southwest—and one of the earliest showings in the country, a 20-min full color, sound motion picture, "Industrial Purchasing." R. G. Glover, Tulsa representative, arranged all details.

Leeds and Northrup Move District Sales Office

The Philadelphia district sales office of Leeds and Northrup Company, manufacturer of electrical measuring instruments, automatic controls, and heat-treating furnaces, has moved from 4901 Stenton Avenue to new and larger quarters at 444 North 16th Street.

The company's advertising department and training school will occupy the remaining space at the new 5-story building address. A large adjoining warehouse is also being occupied by the firm. Areas thus vacated in the main plant on Stenton Avenue will be available to meet increasing needs.

Century Geophysical Crews. Pictured above are 60 crew members, representing five of the eight Century crews operating in Canada. Immediately under the Canadian flag Opie Dimmick, also president of Century Geophysical Corporation, Tulsa, Oklahoma, congratulates Winston Locker on his five years' service with the company. To the left of Dimmick is Archie Nicol, supervisor. Standing at the extreme left is James K. Ziegler, vice president in charge of Canadian operations for Century. Second from right, standing, is Ben Rummerfield, executive vice-president of the Canadian company and vice-president in charge of field operations for the Tulsa company.

Find out about America's finest Field Home —

The Whitmor distinctive field home is outstanding because of the variety of designs, the method of site fabrication that gives you a conventionally built house, at no extra cost. If you prefer, you can have Whitmor homes on a lease-rental plan (Write for complete descriptive illustrated brochure about Whitmor field housing).

MAIL COUPON TODAY

WHITMOR HOMEBUILDERS, INC.
5525 East 15th St. • Tulsa, Okla.

NAME.....
COMPANY.....
ADDRESS.....
CITY.....ZONE.....
STATE.....

ARMSTRONG BROS.
Better PIPE TOOLS

CHAIN TONGS

"Reversible," "Standard" and "Ideal" types in all sizes. Jaws are drop forged from special steel, are carefully milled, heat treated, hardened and tested. The *Handles* are forged spring steel. The *Chains* are proof-tested to ⅔ catalog strength (1,200 lb. to 40,000 lb.). "Reversible" Jaws give double jaw life. "Standard" Jaws have extra bearing on the handle and forged-in chain guides. The "Ideal" Tongs have V shaped teeth for a sure grip on irregular shapes — fittings, etc.

Write for Catalog

ARMSTRONG BROS. TOOL CO.
"The Tool Holder People"
52 W ARMSTRONG AVENUE • CHICAGO 30, ILL.

TRADE PERSONALS

Clyde Lietzow, formerly with the Pelton Water Wheel Company, has been named manager of the Dallas, Texas, office. He has been active in the Pelton sales and service departments in the

California oil field during the past six years. He is a graduate of the University of Michigan.

Tom Garrison is named California sales and service engineer working out of the Los Angeles office, replacing Lietzow. **W. A. McKnight** directs activities at Pelton's Houston office.

Managing the Odessa office is **Gene Bell,** assisted by **N. N. (Gene) Bagley.**

A. C. Cronkrite has resigned his position as vice president, central region sales, Universal Atlas Cement Company, a U. S. Steel Corporation subsidiary. Cronkrite rose from office boy to vice president during his 52-yr career with U. S. Steel subsidiaries. His first job was as office boy with American Steel and Wire Company. He was elected to the vice presidency in 1937.

George S. Neel, western region sales manager, has been named vice president, central and western region sales.

A graduate of Drake University, Neel joined Universal Atlas in 1919 as a salesman.

J. D. Lowd

Judson D. Lowd has been appointed assistant general manager, pressure vessel operations, of The Parkersburg Rig and Reel Company. Lowd will continue to be in Houston, where, until he was appointed to his new position, he served as manager of pressure vessel sales.

Gordon Staub and **Donald D. Reichert** were assigned to the Chicago, Illinois, district, as territory salesmen for Monsanto Chemical Company. **William R. Bone** was assigned to the St. Louis, Missouri, district, **William P. Sheppard** was assigned to the New England territory and **Richard T. Bethel** was assigned to the New York territory. The newly formed merchandising division is handling the sales of Krilium soil conditioner and other trade-marked products through retail channels.

Franklin S. Wade, chairman of the board of directors, Southern California Gas Company and **Dudley E. Browne,** comptroller, Lockheed Aircraft Corporation, have been named members of the board of directors of the Fluor Corporation, Ltd. They replace F. M. Stephens, vice president of Fluor's manufactured products division, and John F. Gardner, head of the project coordination department, both resigned. Wade is a graduate of USC, and Brown attended UCLA.

F. C. McNicol has been named division manager, industrial control sales, Cutler-Hammer, Inc., and **P. C. Foote,** assistant manager, foreign sales. McNicol joined Cutler-Hammer in 1935 as a member of the Milwaukee, Wisconsin district sales office. He became assistant manager of resale sales in 1944. Foote joined the company upon graduation from Cornell University in 1941. He was attached to the Milwaukee district sales office from 1946 until his new appointment.

T. M. Johnston

T. M. (Tommie) Johnston has been transferred from the West Coast offices Los Angeles, California, to company headquarters in Houston, Texas, by Johnston Testers, Inc., and appointed executive vice president, assistant to W. B. Taylor, president. Johnston has been a vice president of the company since its formation in 1951, to purchase the complete assets of four companies from M. O. Johnston. He entered the well testing business with M. O. Johnston in 1932.

D. O. Smith has been appointed assistant manager of Oil Well Supply Division of United States Steel's Gulf Coast area. Smith joined "Oilwell" in 1924 as a draftsman at its Imperial Works plant of Oil City. In June, 1945, after 11 years in sales and management positions in "Oilwell's" eastern division, Smith was transferred to the company's home office in Dallas as supervisor of sonnel and training. He was formerly Midwest area manager in Midland.

J. Fred Forster, who is one of the most widely known pipe line equipment representatives in the South, will head a new department recently established at the Dallas plant of Browning-Ferris

J. F. Forster B. D. Williams

Machinery Company. Forster will supervise representatives of the firm in the various sales territories in North, East, and West Texas, as assistant sales manager. **Barney D. Williams** is general sales manager for the three Browning-Ferris plants at Dallas, Greggton, and Lubbock. **Erle Breithaupt,** Browning-Ferris territory salesman, will assume Forster's duties as pipe line equipment representative.

D. L. Turner

Don L. Turner has been named sales coordinator for Franks Manufacturing Corporation. A veteran of 12 years service with the company, Turner is rejoining the Franks organization after an absence of four years, which he spent in the automotive sales business. Turner succeeds R. G. Jones, who has been advanced to field sales representative in the West Texas area.

Bill Williams has been named director of sales training for Black, Sivalls & Bryson, Inc. His appointment places him in charge of sales training for all sales divisions of the company. Williams will have headquarters at BS&B's Kansas City offices. Formerly associated with Buick motor division, General Motors Sales Corporation, Williams was assistant zone manager, Kansas City. Williams attended the University of Arizona and received his law degree from Southern Methodist University.

G. H. Moore

G. H. (Jerry) Moore has been appointed sales representative for the North Central Texas area, Web Wilson Oil Tools, Inc. He has been driller for Corbett - Barbour Drilling Company, and field engineer for Emsco. His past experience qualifies him to be of real service to Web Wilson Oil Tools.

Trade Personals

J. G. King

J. Gordon King, vice president of Owens-Illinois Glass Company and manager of glass container production, has been named general manager of the Kaylo division. He succeeds **Thomas A. Collins,** who is resigning to accept a position with another company. King, a graduate of McGill University, joined the general manufacturing division of Owens-Illinois in 1932. He was named vice president and manager of glass container production in 1948. In his new position he will be in charge of all phases of operations in the Kaylo division.

Admiral A. G. Noble, USN, (Retired), has been named executive vice president; a member of the executive committee, and a member of the board of directors of the Nordberg Manufacturing Company. Admiral Noble comes to Nordberg from Martin-Parry Corporation of Toledo, where he was vice president and general manager since his retirement from the Navy.

He is a graduate of the Naval Academy and M.I.T.

Edwin A. Desmond has been named head of a new section in the technical service division of Ethyl Corporation. The new section will be concerned with diesel engines, diesel fuels and diesel fuel additives. Desmond joined Ethyl as a student engineer in 1939, after receiving his mechanical engineering degree from Pennsylvania State College. He was engaged in automotive and aeronautical research projects at Ethyl's Detroit laboratories until he entered Navy submarine service in 1943.

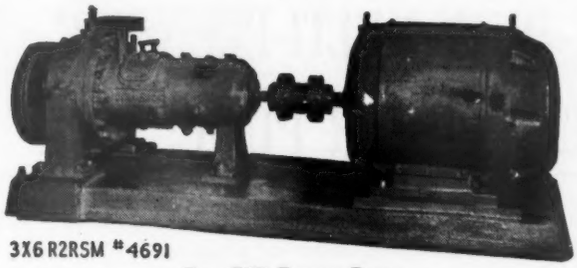
F. H. Ebbert has been named vice president and general sales manager of Gustin-Bacon Manufacturing Company. Ebbert has been vice president and sales manager of the company's automotive division since 1946. In his new capacity, he will have charge of the company's four sales divisions, which are glass fiber insulation products, industrial, railroad, and automotive.

F. H. Ebbert

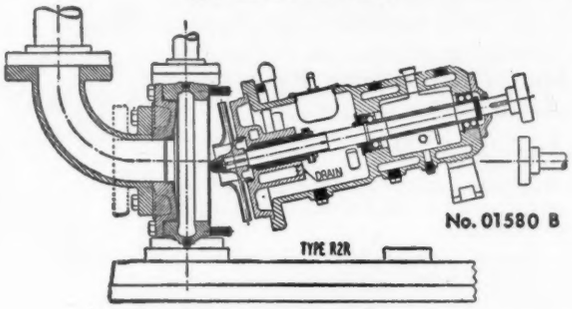
W. E. Watson, former manager of the pump manufacturing division of Fairbanks, Morse and Company, has been promoted to assistant to the manager of manufacturing with headquarters in Chicago. **Paul R. Flood,** who, since 1950, has been manager of manufacturing of the company's Beloit, Wisconsin, works, has been transferred to Pomona, California, where he has been appointed general manager of the company's Pomona Pump Works succeeding **Charles L. Barrett** who has become a consultant to the pump division.

DEAN BROTHERS PUMPS INC.

Type R2R Centrifugal Process Pumps



Type R2R Process Pump



Type R2R Process Pump

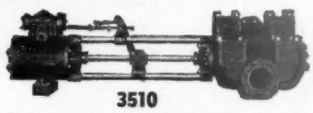
DISASSEMBLY: The Type R2R process pumps can be disassembled without disconnecting the suction and discharge piping. By first removing the spacer from the spacer type coupling, and unbolting the casing from the cradle the entire cradle and complete rotating element can be removed without disturbing the suction and discharge piping.

OPERATING RANGE: Type R2R, Heavy duty, process pumps are available in eighteen different sizes, enabling our engineers to furnish units specially designed and constructed for the particular work to be performed.
Capacities: 50 to 2000 Gallons per minute.
Heads: Up to 400'. Speeds: 900 RPM to 4000 RPM.

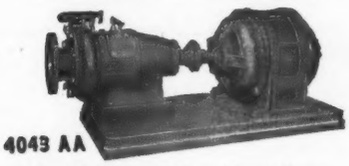
BUILDERS OF OUTSTANDING PUMPS SINCE 1869

CENTRIFUGAL AND RECIPROCATING PUMPS

Close Coupled Centrifugal Pump

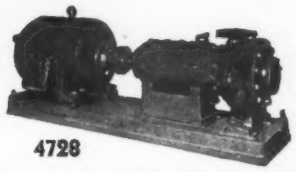


Horizontal, Single Style, Double Acting, Piston Type, Close Clearance Pump. Designed to handle volatile liquids

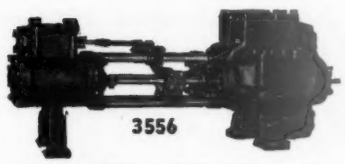


Pedestal Mounted Centrifugal Pump

Horizontal, Duplex, Double Acting, Side Pot, Piston Type, Oil Bath Power Pump



Double Pedestal Bearing Centrifugal Pump



Durable Duplex Packed Piston Pattern Steam Pump, Side Pot Type

ESTABLISHED 1869

DEAN BROTHERS PUMPS INC.

INDIANAPOLIS IND.

323 W TENTH ST.

Branch Offices: NEW YORK, N. Y., HOUSTON, TEXAS

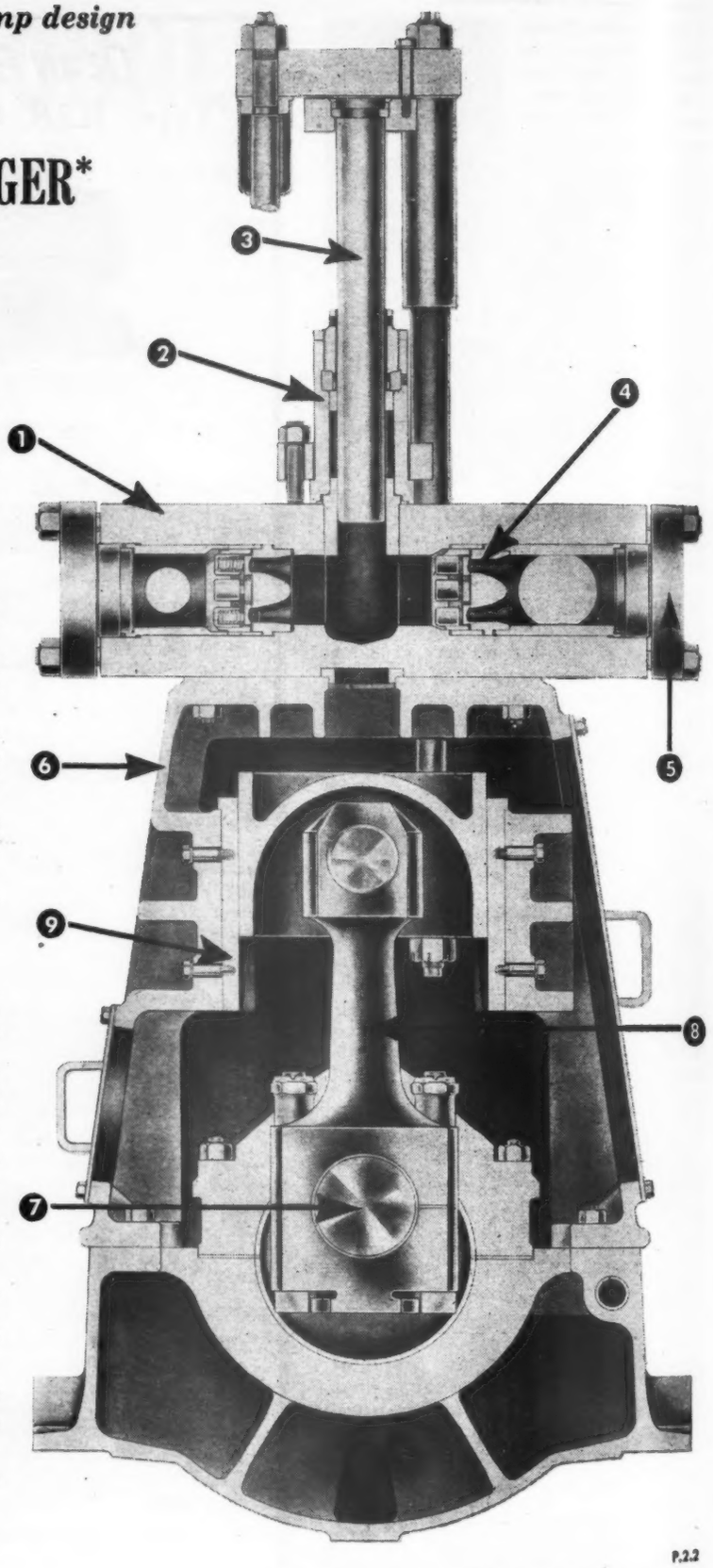
Representatives in Principal Cities

To obtain more information on products advertised see page E-61

The inside story of a new power-pump design

THE WORTHINGTON HEAVY-DUTY MULTI-PLUNGER* VERTICAL POWER PUMP

To users of Worthington pumps, "heavy-duty construction" is almost taken for granted. But when Worthington engineers make a special effort to put *extra* ruggedness into a pump, you have something comparable to this Worthington Multi-Plunger Power Pump. Study the features and see for yourself!



ON THE LIQUID END

1. LIQUID CYLINDER—made of forged steel with large fluid passageways bored from solid forgings for maximum strength.

2. STUFFING BOXES—forged-steel barrels, bolted directly to cylinder with extra-deep boxes that permit maximum interchange of plunger sizes.

3. PLUNGERS—made from hardened and ground alloy steel or any other suitable metal. Solid ceramic plungers can be furnished for corrosive applications.

4. VALVE SERVICE—stainless-steel, heat-treated valves and valve seats. High-strength valve springs and bolted valve-hole covers.

5. INDIVIDUAL VALVE HOLE COVERS—one for each valve, permits quick and easy access.

ON THE POWER END

6. CAST-IRON FRAME—totally enclosed, with design that permits torque to be applied near foundation. All bearing surfaces and running parts pressure lubricated.

7. ONE-PIECE STEEL CRANKSHAFT—one-piece forged steel, accurately turned and ground to size. Heavy sections for minimum shaft deflection when loaded.

8. CONNECTING ROD—marine-type, forged-steel, with steel-backed, babbitt-lined crankpin bearings and solid bronze crosshead pin bearings.

9. CROSSHEAD CRADLE LINERS—solid cast iron with bronze liner shim adjustable to permit careful alignment.

10. BRONZE-SHELL MAIN BEARINGS†—two-piece bronze shell design babbitt-lined with large bearing surface for longest-life. Precision made for trouble free operation.

If your application calls for a power pump of this size, *or any other size*, write, stating specific requirements, to Worthington Corporation, Reciprocating Pump Division, Harrison, New Jersey.

*available in 3, 5 or 7 plunger arrangements (300, 500, 700 hp)
†not shown in drawing

P.2.2

WORTHINGTON
Power Pumps

The World's Broadest Line Assures You the Right Pump for Every Job

William Neundorfer has been appointed to handle the sales of Childers aluminum weather-proof jacketing for The W. M. Acker Organization, Inc. The Acker Organization is the engineering representative for Childers jacketing in the Cleveland, Ohio, area. Childers jacketing is a product of the Childers Manufacturing Company, Houston, Texas. Neundorfer is an engineering graduate of Case and Fenn Colleges in Cleveland.

E. H. Nielsen has been named assistant district manager of Dowell Incorporated, **W. F. Brown** is new district sales manager and **M. E. Hanson,** district area manager. Nielsen will direct Dow-

Neilsen

Brown

Hanson

ell's activities in the Rocky Mountain area. He joined Dowell in 1944. Brown, who joined Dowell in April 1936, will handle and correlate sales training and sales development throughout the entire district. Hanson will oversee Dowell developments in the Eastern part of the Wichita, Kansas, district. He joined Dowell in 1946.

A. J. Lacock

F. J. Swenson

A. J. Lacock has been appointed director of purchases of Foster Wheeler Corporation and will be responsible for the operations of the general purchasing department. Lacock replaces **F. J. Swenson,** who has been with Foster Wheeler since 1921 and will remain active as special assistant on purchasing problems. Lacock, who is an industrial engineer, was with General Electric for 17 years.

Norman K. Rector has joined the staff of Walco Engineering and Construction Company as chief design and process engineer. From 1950 until joining Walco, Rector worked as an independent consulting engineer in the natural gasoline plant field. A former engineering student at Oklahoma A & M College, Rector began in the petroleum field with the Marland Oil Company at Ponca City in 1926.

James F. Clark, formerly vice president and treasurer, has been named American Car and Foundry Company vice president in charge of finance. **John F. Burditt,** assistant treasurer for a number of years, was elected treasurer of the company.

A. J. Swisler

G. A. Banton

Anthony J. Swisler has been appointed as regional manager for the West Coast and **George A. Banton** district manager, Southern California and Arizona territory, for Whitney Chain Company. Swisler joined the company in 1943, after many years of diversified activity in mechanical engineering fields. Following his first assignment in the company's Los Angeles office, he was appointed district manager in 1950. Banton has been with Whitney for 2 years. For 10 years prior to that, he was engaged in sales engineering work.

Edward H. Blakestad and **George M. Fullwood** have been named sales representatives in Allis-Chalmers general machinery division's Tulsa and Dallas district offices, respectively. Blakestad is a mechanical engineering graduate of Oklahoma A. & M. Fullwood received his electrical engineering degree from Southern Methodist University.

LUFKIN

TAPES • RULES AND PRECISION TOOLS

"STANDARD OF ACCURACY" for the oil industry!

EASY TO READ MARKINGS THAT ARE DURABLE

There is a Lufkin steel tape for your every measuring need — tank strapping, derrick work, tank gaging, or general measuring. Lufkin Chrome Clad steel tapes are accurate, tough, and durable. The figures and graduations are an integral part of the line — can't wear off. The line won't chip, peel, or crack. The jet black markings are easy-to-read against the chrome-white background. Mail coupon below for booklet describing Lufkin Tapes, Rules and Precision Tools used in the Oil Industry.

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THE LUFKIN RULE CO., Dept. PE, Saginaw, Michigan

Gentlemen: Send me your free booklet, "Lufkin Tapes, Rules and Precision Tools for the Oil Industry."

NAME_____

COMPANY_____

TITLE_____

ADDRESS_____

CITY_____ STATE_____

W. B. (Bill) Whitcraft and R. J. (Russ) Gamberg, have been named sales engineers of Lane-Wells Company, in the Mid-Continent division. Gamberg is a graduate of the South Dakota School of Mines. He joined Lane-Wells in 1950 and is currently in the Casper, Wyoming, office. Russell, Kansas, is the home base for Bill Whitcraft. A graduate of the U. S. Maritime Academy, he began his Lane-Wells career in 1948.

E. Reichhelm

Edward Reichhelm has been appointed manager of the recently established eastern sales and export office of Hudson Engineering Corporation, New York City. Reichhelm attended Colgate University, and for the past 20 years has engaged in engineering, and sales of process equipment to the petroleum and chemical industries in the New York area. He previously was with the New York sales office of Alco products division of American Locomotive Company.

F. Eugene Englander has been appointed sales manager of the Richmond division of Gar Wood Industries, Inc., Richmond, California. Englander attended the University of California and Ohio State University. He joins Gar Wood from Oscar Krenz, Inc., where he was sales manager.

More Power—Less Cost
SAND-BANUM
REMOVES AND PREVENTS BOILER SCALE AND CORROSION
Longer Equipment Life
Fewer Shut-downs
Write for Details
SAND-BANUM SPECIAL
TABLETS REMOVE AND PREVENT RUST AND SCALE IN ALL RADIATOR COOLING SYSTEMS
Easy to Use
Fully effective regardless of water or operating conditions.
AMERICAN SAND BANUM CO.
Established 1926
9 Rockefeller Plaza
New York 20, N.Y.

Gose

Anderson

DeWitt

Carson

Bleakie

Emory E. Gose, Jr., vice president and treasurer of Tellepsen Construction Company, has been named director of the petroleum and chemical division. He has been associated with Tellepsen Construction since 1937.

H. M. Anderson has been named chief engineer. A former student of electrical and petroleum engineering at Kansas State and Oklahoma universities, Anderson was employed by the Fluor Corporation for nine years. For the last six years, he has been with Brown and Root.

Appointed manager of the construction section is **Lyle S. DeWitt,** a graduate engineer of the Missouri School of Mines. **O. L. "Kit" Carson,** an Oklahoma University engineer, will be sales manager of Tellepsen's petroleum and chemical division.

Assisting Carson will be **Paul F. Wolfinger,** sales engineer. He is a graduate of Oklahoma A. & M. The estimating and analytical section will be headed by **Joseph S. Bleakie,** chief estimator, who holds a B.S. degree from Harvard.

Don Hathorn has been named new manager of Halliburton Oil Well Cementing Company's mechanical research and development department. The mechanical research and development department conducts basic and applied mechanical research on Halliburton services, tools, and equipment. Hathorn, patent engineer for Halliburton for 15 years, is a graduate of Oklahoma A. & M.

Sydney Heldon has been appointed to the territory of Eastern Pennsylvania, New Jersey, Maryland, and Washington, D. C., by New Bedford Cardage Company. He will operate out of Philadelphia and will replace **H. C. Conkling, Jr.,** who was moved to assistant sales manager in New Bedford, Massachusetts. Heldon has over 15 years of selling experience and more than 20 years of business background. He was graduated from Arncliffe Commercial College, Sidney, Australia.

F. Shlemmer

Frank Shlemmer has joined Pacific Valves, Inc., as Eastern Coast divisional sales manager, with his headquarters at 122 East 42nd Street, New York City, New York. Shlemmer was former purchasing agent for The Texas Company in Los Angeles for a number of years and for the past four years he has been purchasing agent for Texaco in New York City.

John R. Gilmartin has been named general sales manager of the Hyatt Bearings Division of General Motors in Harrison, New Jersey. Gilmartin succeeds **Howard K. Porter** who has been named assistant to general manager on special assignments. Gilmartin joined the Hyatt Bearings Division in Detroit upon his graduation from the University of Michigan in 1929. Porter joined the Hyatt Bearings Division in 1916 and during the years held various engineering and sales positions at Harrison.

H. F. Ziegler, Jr.

Herbert F. Ziegler, Jr., has been named manager of the Kansas City, Missouri, district office of Sterling Electric Motors, Inc. Ziegler is a graduate of Notre Dame. After service in World War II as Lieutenant j. g. in the Navy, he took post-graduate work at the University of Friborg in Switzerland. Since that time he has gained wide and varied experience in industrial sales.

Burton W. Graham has been named director of technical service of The Davison Chemical Corporation it was announced by D. N. Hauseman, vice president. He was formerly assistant general sales manager, industrial chemical department, and is succeeded in that post by **D. P. Barrett,** formerly in charge of the company's New York sales office.

Graham has a BS degree in chemistry from Maryville College and a MS from the University of Florida.

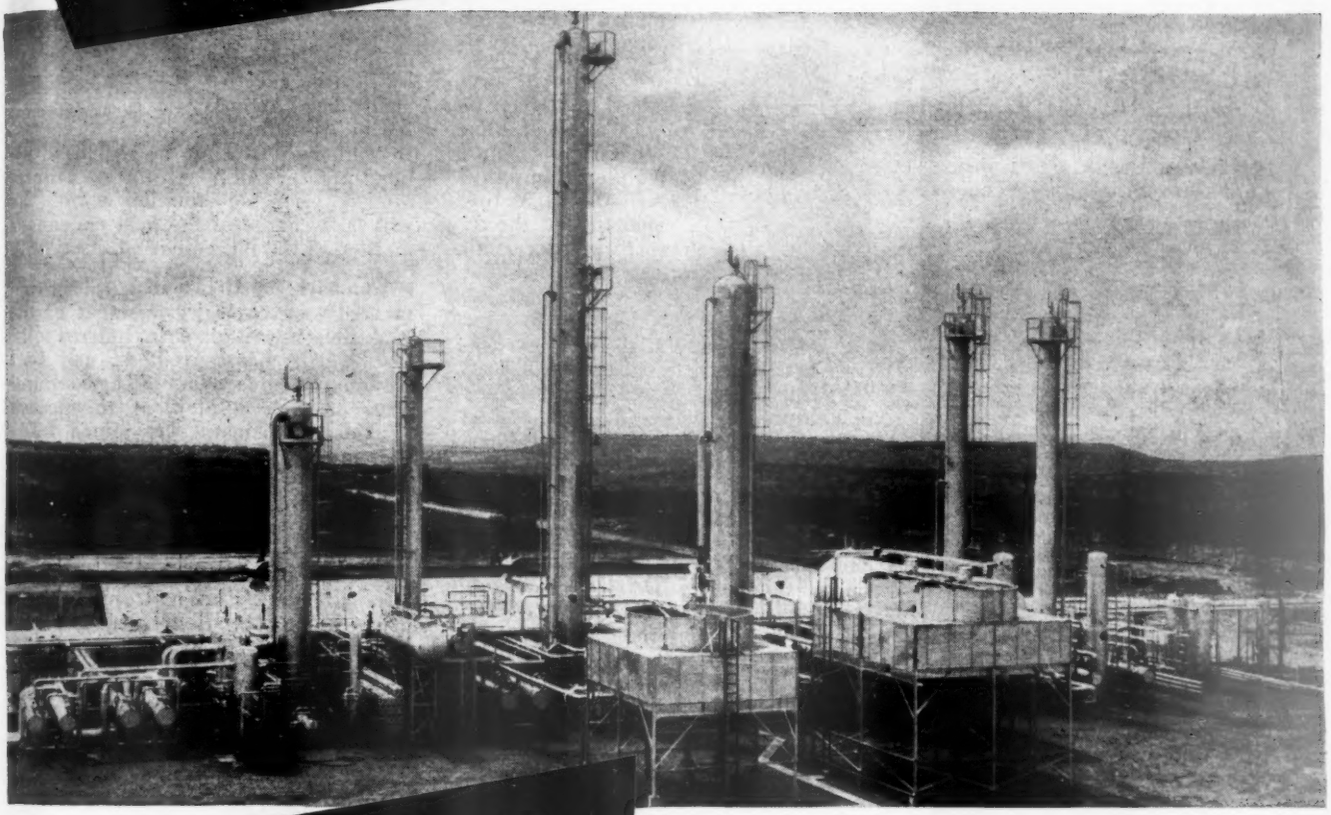
J. C. "Joe" Miller is now executive engineer in charge of all product engineering and research activities for Cummins Engine Company, Inc., Columbus, Indiana. He had been manager—research and refinement.

D. B. "Dan" Worth becomes manager—field quality. In this position he will coordinate field and factory studies of product quality control. Until this appointment Worth had been manager—product engineering.

N. M. "Nev" Reiners is now manager—research and refinement in charge of the company's research activities. He had been manager—research laboratory. A graduate of the University of Michigan, Miller had joined Cummins in 1947. Worth began with Cummins in 1936 as a sales engineer. He graduated from North Carolina State College.

Reiners joined Cummins following his graduation from North Dakota State.

Reduce Fouling in your plant



with BROWN FINTUBE sectional hairpin heat exchangers

● Brown Sectional Heat Exchangers, with their integral one-piece extended surface fintubes, reduce fouling, just a few hundredths of an inch of which on a tube causes a major loss in heat transfer efficiency.

These exchangers assure efficient operation at low "skin" temperatures, minimizing coking and building up on the fintubes. And the controlled flow through the longitudinal passages keeps all the material in continuous motion. There are no baffles, back-eddies or stagnant areas to encourage fouling.

For top operating efficiency and reduced fouling use Brown Sectional Heat Exchangers throughout your plant. ***Write for Bulletin No. 521***

THE BROWN FINTUBE CO.
Elyria, Ohio

Sectional Hairpin Heat Exchangers
Tank Suction and Line Heaters
Fintube Heaters for Bulk Storage Tanks
Indirect Process Air Heaters
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▸ **Ian K. MacGregor** has been appointed director of manufacturing of the Consolidated Ashcroft Hancock division of Manning, Maxwell and Moore, Inc. MacGregor, a former vice president of Campbell, Wyant, and Cannon in Muskegon, Michigan, was born in Scotland and graduated from the University of Glasgow. At one time with the engineering plants of Scottish Clydeside, he came to the United States in 1940.

W. N. Shepard

▸ **Whiting N. Shepard** has been promoted to director of sales of the Boston Woven Hose and Rubber Company. As sales director, Shepard has the responsibility for all marketing activities of the company, which was founded in 1880 as the country's first producer of woven fire hose. Shepard joined Boston Woven Hose in February of this year after 19 years with the Plaskon division of Libbey-Owens-Ford Glass Company of Toledo, Ohio.

▸ **Edward F. Whittemore** has been named purchasing agent for Morse Chain Company's Detroit, Michigan, plant. The responsibilities that Whittemore will assume include procurement, follow-up, and priorities control. Whittemore comes to Morse Chain from the New Holland Machine Company.

▸ **J. L. Roberts** has been named to Enterprise Engine and Machinery Company's engine and reduction plant field engineering and service. He will be associated with **Paul Wabnig** in New Orleans, Louisiana. He is former assistant manager of the process division specializing in reduction plant work.

J. L. Roberts

▸ **Ray E. Gorman** has been appointed Mid-Continent representative, Web Wilson Oil Tools, who will assist Mid-Continent, Rocky Mountain, and Western Canada sales agents. Gorman will continue temporarily at Wichita, Kansas, until establishment of permanent offices at Dallas in the near future.

Kansas and Eastern Nebraska will be covered by **Noel Swick** who will have his office at Great Bend, Kansas. Swick has been assistant to Gorman for the past three years.

William J. (Bill) Davis has transferred to the Oklahoma and Texas Panhandle territory and will have his headquarters at Oklahoma City.

George S. Badger has been appointed Canadian sales agent for Web Wilson, and will be assisted by **John Harvie, Bernie Davis,** and **Hugh Calder,** all well known in Canada. Badger's headquarters are at Calgary.

▸ **E. D. Anderson,** chief engineer for Western Supply Company's heat exchanger division, has been appointed an industry member of the engine and turbine division of the National Production Authority in Washington. According to Hughes, Anderson will take a three to four months leave-of-absence from the Tulsa firm, effective September 1, returning to Tulsa in late December. Meanwhile he will have his headquarters in Washington, where, after a brief indoctination period, he will take charge of the heat exchanger division of the NPA division.

E. D. Anderson

▸ **Kendrick M. Hickman** has been appointed assistant sales manager of the Link-Belt Ewart plant in Indianapolis, for Ewart general products, and **Carl Rudman** as manager of agricultural sales at the Ewart plant to succeed Hickman. Hickman, who joined Link-Belt in 1927, assumes the duties of **H. M. Bowman,** who is being transferred to the Chicago Pershing Road plant to devote full time to sales promotional activities.

Rudman joined Link-Belt in 1937, after attending Purdue University. He began in the Link-Belt Dodge plant in Indianapolis.

▸ **C. Fred Naylor** has been promoted to the new position of manager of personnel development in Ethyl Corporation's sales department. Naylor, who joined Ethyl in 1931 as a field representative, has been assistant manager of the company's Western sales region at Los Angeles since 1950. **Monroe F. Weill,** district manager at Los Angeles succeeds Naylor as assistant regional manager. Weill, a graduate of Purdue University, joined Ethyl in 1939. **Ellis K. Locher,** formerly manager of safety, is being transferred from New York to Los Angeles, and succeeds Weill as district manager. Locher joined Ethyl in 1936. He is a mechanical engineering graduate of Cornell University. **Levan R. Fleck,** who has been assistant safety manager, succeeds Locher as manager of safety. Fleck, a graduate of the University of Pittsburgh, joined Ethyl in 1937.

▸ **Robert D. Walker** was recently appointed to The Weatherhead Company staff of industrial sales engineers and will handle sales of Weatherhead Ermeto tube fittings, a full line of other types of tube fittings and hose assemblies with reusable or fixed ends. He will cover Arkansas, Louisiana, New Mexico, Oklahoma, and Texas. Walker, a member of Nomads, has 20 years experience in many phases of hydraulics.

R. D. Walker

Holcomb

Harrallson

McCelvey

C. J. (Chuck) Holcomb, who has recently been transferred to Well Equipment Manufacturing Corporation's home office in Houston from Corpus Christi, Texas, has been made an industrial sales representative. In his new capacity, Holcomb will contact industrial firms, refineries, and chemical plants throughout the Gulf Coast and Mid-Continent areas for WECO.

J. R. (Rudy) Harrallson has been named New Mexico-West Texas representative, with headquarters in Hobbs, New Mexico, for Well Equipment. For the last two years Harrallson has been with Dunigan Tool and Supply Company. He replaces **L. L. Durkin,** who is transferring to Denver, Colorado.

J. C. McCelvey has been named assistant sales manager of WECO. McCelvey's appointment will give Well Equipment two assistant sales managers, which has been necessitated by the recent addition of the Rocky Mountain area to WECO's sales territory. With Well Equipment since May of 1938, he is their oldest sales representative in years of service.

J. H. Brinker

J. H. Brinker has been appointed assistant executive in charge of distribution at A. O. Smith Corporation, Milwaukee, Wisconsin. He moved into the new position this month from his former assignment of general sales manager for A. O. Smith's southwest district, with headquarters at Houston, Texas.

Brinker is a University of Rochester graduate of 1936. Following his discharge from the Navy, he attended Harvard Business School, where he was awarded a master's degree in business administration.

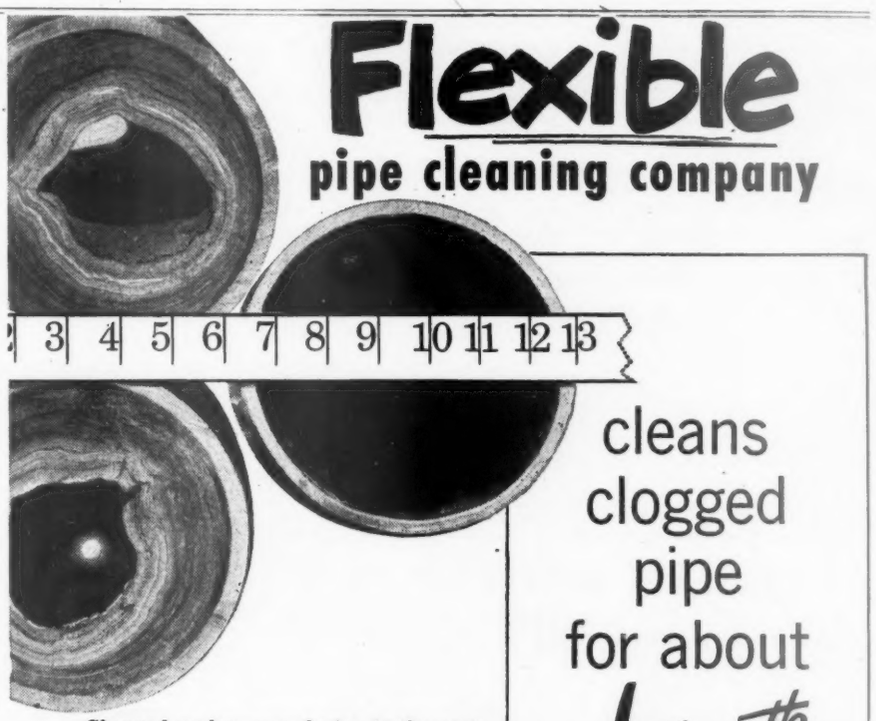
Jack E. MacConville, has been named industrial sales manager of the Southeast region with headquarters in Atlanta, Georgia, for Minneapolis-Honeywell Regulator Company. Other appointees are: **Alfred J. McCullough,** Central region, headquarters in Cleveland, Ohio; **Howard L. Marston,** the Northwest, headquarters in Minneapolis, Minnesota; **Robert L. Mallory,** Southwest, headquarters in Dallas, Texas; **Robert B. Grant,** Pacific and Mountain regions, headquarters in Los Angeles; **Lester W. Williams,** Pacific Northwest, Portland, Oregon, and **John A. Robinson,** manager of the Eastern and Mid-Atlantic regions.

Lawrence C. Burdette has been promoted to manager of the Parkersburg, West Virginia, store of U. S. Steel's Oil Well Supply Division. Burdette joined "Oilwell" at the Parkersburg store in June, 1947, following his graduation from Parkersburg High School and has been employed at that location since that date.

Dr. Albert E. Griffiths, formerly of the Socony-Vacuum Oil Company, has joined the chemical sales division of Ethyl Corporation. He will supervise technical service work connected with the corporation's agricultural chemicals. Dr. Griffiths attended Cornell University, receiving his B.S., M.S., and Ph.D. degrees there.

Arthur C. Ombert has been named director of engineering and research for the Bendix radio division of Bendix Aviation Corporation. **A. E. Abel** has been named as his assistant. Omberg succeeds **W. L. Webb** who was recently promoted to the central engineering staff of the Bendix Aviation Corporation, in Detroit. Omberg, who has been associated with Bendix since 1944, has been assistant director of engineering and research for the past two years. He attended Southwestern and Vanderbilt Universities.

Abel, who will become assistant director of engineering and research has been chief radar engineer for the radio division responsible for design of both the military and civilian radar.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BOOKS

The Memoirs of Herbert Hoover, *Vol. III, The Great Depression, published by The MacMillan Company, 60 Fifth Avenue, New York 11, New York. Price, $5. Pages, 485.*

This third volume makes an analysis of the Great Depression, the beginnings during the Hoover administration, and the eight years of New Deal power from 1932-1940. Mr. Hoover argues that the boom and crash of 1928-29 were largely the responsibility of the Federal Reserve Board, which acted against his protest; that the bank panic of 1933 was the most unnecessary panic in history, and that Roosevelt's action as President-elect tended to precipitate the panic and his refusal to cooperate had an adverse effect on critical foreign problems. In Part One he describes the five stages of the United States depression. He points out the many constructive steps his administration took to counteract the crisis.

The final section of this third volume describes the failure of Roosevelt under these policies to achieve domestic recovery, and gives a critical analysis of those times which, he believes brought about our present domestic crisis.

Compilation of State Tax Law Relating to Oil, Gas, and Mining Properties in New Mexico, *Bulletin 32, by E. P. Ripley. Published by State Bureau of Mines and Mineral Resources, Campus Station, Socorro, New Mexico. Price, $1.50. Pages, 56.*

This booklet is divided into three sections dealing with 1) ad valorem and production taxes, 2) severance taxes and 3) sales taxes. In order to make this compilation of some benefit, reproduction of the forms currently used are appended. Decisions of the Supreme Court are also mentioned, though no attempt is made to cover court decisions in detail. This compilation does not deal with corporate taxes nor with state income tax.

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Basic Mathematics for Engineering and Science, *Van Voorhis and Haskins. Published by Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, New York. Price, $7.65. Pages, 611.*

This new text in college first-year mathematics, gives a working knowledge of algebra, trigonometry, and analytic geometry. Algebra, trigonometry, and analytic geometry are handled, each in turn. The presentation is slanted toward the needs of engineering and science students through the constant use of applications from their fields. Problems and illustrations are put in terms of mechanics, physics, electricity, and chemistry. Explanations are designed to be largely self-teaching. The charts and graphs were chosen to give the students an immediate visual grasp of the applications. Eight tables are included and many problems are given, with answers at the end of the book.

Electrical Well Logging Fundamentals, *by Hubert Guyod, P. O. Box 2406, Houston, Texas. Price, $3.25. Pages, 164.*

This booklet contains an original printing of two papers and two charts, and a reprinting of most of the author's papers on electrical logging, including the series of sixteen articles published in The Oil Weekly, and some recent papers such as "Resistivity Departure Charts," "The Shielded-Electrode Method," and "Principles of Microlog Interpretations." Some new sections cover "The Induction Method and Resistivity and Potential Range of Common Sediments." Another significant addition to the author's previous work is a comprehensive "Bibliography on Electrical Logging" in which the items are classified chronologically under nineteen different subjects.

Spindletop, *by James A. Clark and Michel T. Halbouty. Published by Random House, 457 Madison Avenue, New York 22, N. Y. Price, $3.95. Pages, 298.*

"Spindletop" is the true story of the oil discovery that changed the world—of the events leading up to it, and of the boom days that followed. The first great American gusher changed the town of Beaumont, Texas, overnight. Men slept in boarding houses in relays, twenty to a room. At one time the oil was so plentiful that it sold for 3 cents a barrel, while water sold for $6 a barrel. Written by men who have grown up in the fields, this book brings alive the excitement and the bedlam that ushered in this new American era. It is enlivened by colorful portraits of the men who played a part in this great adventure that changed the destiny of industry.

The story of the Lucas gusher, the effect it had upon the men who had a part in bringing it in, the people who lived in the town, the town itself, and on the history of the United States, is told in absorbing narrative form.

The Dicky Bird Was Singing, *by Bob Duncan. Published by Rinehart and Company, Inc., 232 Madison Avenue, New York 16, New York. Price, $3. Pages, 282.*

This is a collection of stories about "men, women, and black gold"—a collection of myths, legends, folklore, and tall tales, which are the personal reminiscenses of the oil industry. The dirt farmers, the hangers-on, the do-or-die scientists, the fakirs, the swindlers, and the swindled, are characterized in these tales, which are funny, sad, and at times informative. The author uses as his theme the story that a bird made of cast iron, "whose voice is found in the hoarse squawk of a walking beam in need of oil," approaches some men early in life; and once a man is visited by this Dicky Bird, he will never find rest until he has cast all else aside into the feverish search for oil. These stories, told by hundreds of oldtimers, are the stories of oil people, reflecting a way of life that is rapidly disappearing, but reflecting an era that made history.

A Manual on Underground Corrosion, *published by Columbia Gas System, Inc., 120 East 41st Street, New York 17, New York. Price, 75¢. Pages, 37.*

This manual was designed to give operating personnel a better understanding of the general problem of corrosion. Three Columbia committees — gas production, gas transmission, and gas distribution — prepared the data. Columbia has received requests for the manual from several other companies, and therefore is making it available.

The manual, which starts with an explanation and illustration of the galvanic cell, is technically thorough and clearly illustrated with 52 drawings. It is written so simply that it can be understood by the layman.